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Annual report

THIRD REPORT OF

THE BUREAU OF MINES

1893.

PRINTED BY ORDER OF THE
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TO HIS HONOR GEORGE AIREY KIRKPATRICK,

Lieutenant-Governor of Ontario :

I have the honor to transmit herewith, for presentation to the Legislative Assembly, the Third Report of the Bureau of Mines.

I have the honor to be, Sir,

Your obedient servant,

A. S. HARDY.

Commissioner of Crown Lands.

DEPARTMENT OF CROWN LANDS,

Toronto, April 27, 1894.



THIRD REPORT OF THE BUREAU OF MINES.

To the Honorable ARTHUR S. HARDY,
Commissioner of Crown Lands:

SIR,—I have the honor to submit herewith, for presentation to His Honor the Lieutenant-Governor, the Third Report of the Bureau of Mines.

Besides the statistics of mineral production in the Province, and of mining lands leased or sold by the Department of Crown Lands last year, this Report deals with several subjects which are attracting notice at the present time.

One of these subjects relates to our gold fields. Last year I visited mines in the Lake of the Woods region, in the district north of Lake Huron and Georgian Bay, and in the county of Hastings, and a full account of operations in those several fields is given in the Report. I also performed the duty of inspecting the several gold mines and mills, and therefore it was not necessary for the Inspector to visit them. The prospect of gold mining in the Province has greatly improved during the year, and with new fields to attract the industrious explorer there is promise of increased activity this year.

Another portion of the Report is devoted to an account of exploratory work undertaken at Point Mamainse, on the east shore of Lake Superior, with the object of ascertaining the value of the copper-bearing formations there, which are identical with the copper-bearing rocks in Michigan, on the southern shore of the same lake.

Our deposits of fibrous talc and actinolite in the counties of Hastings and Addington have also received attention. The talc industry has recently been largely developed in the State of New York, where the value of the yearly output of the mills has reached half a million dollars. With properly directed enterprise there is, I believe, a good field for mining and milling talc and actinolite in this Province also.

Vitrified brick
for street
paving use.

The adoption of vitrified brick as material for street pavement has been made the subject of enquiry by the Secretary of the Bureau, Mr. Gibson. There is no doubt as to the suitability of brick for this purpose, as is amply shown by the experience of American cities; and if, as is almost certain, we have clays for the manufacture of vitrified brick of the right quality—such as our beds of Hudson River and Medina shales—a new industry of no little importance may soon be established in the country. The yearly demand for pavement material in our towns and cities is large and steadily growing: and if we can employ labor and capital to produce a good article at home, it is much better that we should do so than continue dependent on foreign supplies.

Utilization of
peat.

The utilization of peat is a subject that continues to receive attention, and inventors of various processes of treatment for the production of fuel are sanguine of ultimate success. For a paper on other uses of peat I am indebted to Mr. Edward Jack, of Fredericton, New Brunswick.

Report of the
Inspector of
Mines.

The annual report of the Inspector of Mines accompanies the Report of the Bureau.

I have the honor to be, Sir,

Your obedient servant,

ARCHIBALD BLUE,

Director.

Office of the

BUREAU OF MINES,

Toronto, April 27, 1894.

REPORT OF THE BUREAU OF MINES.

I. STATISTICS.

There is not much change to note in the condition of the mining industry when the statistics of last year's production are compared with those of the previous year. There has been a decrease in the quantities and values of building stone and nickel and copper, but this is offset by the increase in the quantities and values of petroleum products. Transactions in mining lands, while showing a noticeable increase in the number of locations leased or sold, are marked by a lowering of average areas. The activity displayed in the earlier part of the year was not maintained in the latter part; but inasmuch as a large proportion of those who take up mineral lands in Ontario are Americans, the falling off was no doubt a consequence of the financial disturbance which overtook them at home.

Comparison
with the pre-
vious year's
statistics.

SALE AND LEASE OF MINING LANDS.

The following table gives the number of patents for mining lands issued last year in each of the several districts, the areas of the locations, and the amounts which the sales realized:

Statistics of
locations sold

District.	No. of patents.	Acres.	\$
Rainy River.....	41	2,390.72	6,856 00
Thunder Bay.....	4	362 50	920 75
Algoma.....	3	410.00	1,113 00
Nipissing.....	3	200 00	622 00
Elsewhere.....	12	1,007.00	1,986 25
Totals.....	63	4,370.22	11,498 00

Included in the above are two patents of mining rights, sold under the provisions of section 19 of The Mines Act 1892. They embrace an area of 186 acres, and the price paid was \$232.50.

The number of patents issued in 1892 was 65, covering 6,200 acres, and the price paid was \$15,273. There was only a difference of two in the number of patents issued in the two years; but while in the former the average area was 95.38 acres, it was in the latter only 69.37 acres.

and of loca-
tions leased

The next table gives the number of mining leases issued in each district, the area covered by them, and the amount received for rent of the first year:

District.	No. of leases.	Acres.	\$
Rainy River.....	68	6,857.00	6,857 00
Thunder Bay	3	360 00	260 00
Algoma	32	3,540.62	3,458 88
Nipissing.....	7	599 63	536 62
Elsewhere	12	1,689.50	821 40
Totals.	122	13,046.75	11,933 90

Included in the foregoing are 11 leases of mining rights, granted under the provisions of section 19, embracing an area of 1,094½ acres, for which the first year's rent was \$401.05.

In 1892 the number of leases issued for mining locations was 95, covering 13,122½ acres, and the amount of first year's rent paid was \$12,314.36—the average area of locations being 138.13 acres as against 106.94 acres in 1893.

The amount of rentals received in 1893 on leases issued in 1891 and 1892 was \$2,735.86, as against \$603 received in 1892 on leases issued in 1891. The total amount of receipts for sales and rentals last year was \$26,167.76, and in the previous year \$28,190.36.

MINERAL STATISTICS.

Building
stone.

The value of the product of 310 stone quarries last year is computed at \$721,000, made up as follows: 1,400,000 cubic feet dimension stone, \$260,000; 44,700 cubic feet heads and sills, \$21,000; 170,000 square yards coursing stone, \$180,000; and 410,000 cubic yards rubble stone, \$260,000. The number of workmen employed at the quarries was 1,700, and the wages paid for labor \$464,000.

Cements.

The manufacture of cements is steadily increasing. There are now four works producing Portland and five producing natural rock cement. Last year the output of Portland cement was 31,924 barrels, valued at \$63,848, and of natural rock cement 74,353 barrels, valued at \$63,567. The number of workmen employed in the industry is 224, and the amount of wages paid for labor \$60,208. Tests of Portland cements used in Toronto show that some of the brands manufactured in Ontario are superior to the imported cements of the same class.

Lime.

The number of lime kilns in operation in the Province is about 300, and last year they produced 2,700,000 bushels valued at \$364,000. The number of workmen employed at the quarries and kilns was 600, and the amount paid for wages \$122,500.

There are in the Province about 350 works for the manufacture of common brick, of which about 150 are also employed in the production of drain tile. The output of these works last year was 162,350,000 brick, valued at \$932,500, and 17,300,000 drain tile, valued at \$190,000. The number of workmen employed in the joint industries was 2,650, and the amount paid for wages \$451,000. Brick and tile.

Six works were employed in the manufacture of pressed brick and terra cotta, the output of which was 20,208,000 plain brick, 1,373,000 fancy brick and 53,000 of roofing tile. The aggregate value of brick, roofing tile and terra cotta products was \$217,373. The number of workmen employed was 224, and the amount paid for wages \$80,686. Pressed brick and terra cotta.

Two companies have been carrying on the manufacture of sewer pipe, one of which was started last year and worked only part time. The average number of men employed was 85, and the amount of wages paid \$34,000. The value of product was \$230,000. Sewer pipe.

There are about forty works in the Province employed in the production of pottery. Last year the total value of wares made was \$115,000, employing the labor of 150 men, whose wage-earnings reached \$36,000. Pottery.

The gypsum industry is making slow progress, and last year only four of the six companies which own mines and works on the Grand river were actively employed. The total quantity of gypsum mined is reported to be 2,958 tons, the greater portion of which was ground into land plaster. The value of raw gypsum and plaster (2,818 tons) is computed to be \$7,363. The rest of the mineral, 140 tons, was manufactured into alabastine and plastico at the new works at Paris, and is valued at \$14,800. The number of men employed at the mines and works was 33, and the amount of wages paid \$9,220. At the alabastine works gypsum is now being used in the manufacture of a potato bug poison, which is claimed to possess the double merit of destroying the bugs and fertilizing the crop. Gypsum and alabastine.

The apatite or phosphate of lime mines of the Province were idle last year, with a single exception; the cheaper production of South Carolina and Florida mines continuing to make operations in Ontario unprofitable at the European prices. One mine was worked for a short time by four men, who raised 20 tons valued at \$200. The cost of labor was \$500. Phosphate of lime.

The salt-making industry remains practically at a standstill, for although the production was greater last year than in the preceding year, the aggregate value was less. The new Canadian Pacific Railway works at Windsor did not begin operations until late in the year, and two other works in Huron were idle. The total output of fifteen establishments was 39,150 tons of fine and 9,300 tons coarse salt, the value of the former being \$123,450, and of the latter \$26,400. The number of workmen employed was 210, and the amount of wages paid for labor, \$44,440. In 1892 the total product was 43,387 tons, valued at \$162,700, and the wages paid for labor \$37,800. Salt.

Mica.

Mica mining was limited to operations on five properties, where 70 tons were produced, valued at \$8,600. Forty workmen were employed, and the amount of wages paid was \$4,500.

Nickel, copper
and cobalt.

With the exception of operations at Point Mamainse on Lake Superior to open up the copper veins there, all mining for copper and nickel in the Province during the year was carried on in the Sudbury district. Five companies were employed in the industry, but owing to financial difficulties one of the works was closed for the greater part of the year. The total quantity of ore raised was 64,043 tons, and the quantity smelted was 63,944 tons. The product of the furnaces was 7,176 tons of ordinary and 452 tons of bessemerized matte, the metal contents of which are estimated to be 1,431 tons copper, 1,642 tons nickel and 19 tons cobalt. Values are computed on the market price of matte at the furnaces, and are for copper, \$115,200; for nickel, \$454,702; and for cobalt, \$9,400, being a total of \$579,302. The average number of workmen employed at the mines and works was 495, consisting of 129 men underground and 356 men and 10 boys under 17 years above ground, and the aggregate of wages paid for labor was \$252,516.70. The running time of the smelting furnaces in the year ranged from 46 to 239 days, and the working time in the mines from 40 to 297 days in the year, the aggregate working time of men under ground being 24,348 days.

A Duluth company began late in the year to open up a promising property on lots 10 and 11 in the third concession of Trill, where a shaft has been sunk on a body of solid ore. It is the intention of this company, if the exploration work is satisfactory, to erect a plant for treating the ore by a new process, from which good results are expected.

Gold.

Fifteen gold properties were worked during the year, upon which labor was expended to the amount of \$49,027. The average number of men employed above ground on all the properties was 112, and below ground 56. The work however was chiefly of a development character, the cost of which bears no relation to the gold product. Nine mills for treating ores were in operation, but none of them for a long period. Four of these were Crawford mills, four were stamp mills, running a total of fifty stamps, and one a mill for treating refractory ores. The latter was an experimental plant, erected to test a new process of extracting gold from mispickel, and its capacity is only five tons per day. Two of the stamp mills were completed only a few days before the close of the year, another was closed down for repairs for several months, and the fourth was idle for nearly the whole of the year. The Crawford mills do not appear to have given much satisfaction where they were tried, and none of them were run for more than a few days. The total quantity of ore treated during the year was 5,560 tons, which yielded 1,695 ounces of bullion, valued at \$32,960.

Silver.

Silver mining was inactive throughout the year. All the producing mines were shut down in consequence of the depreciation of silver, and the only work done was of a development character. Five men were employed for sixty days at a cost for wages of \$400. The quantity of ore produced was 500 tons, with a nominal value of \$2,500.

The shipments of crude and refined petroleum from the Petrolea and Oil Springs fields for the year ending 31st October was 1,045,000 barrels, reckoned in the equivalent of crude; but the produce of the year was 72,000 ^{Petroleum.} barrels less. The yield of the Petrolea field was 795,131 barrels, and of the Oil Springs field 177,869 barrels, or 34,055,000 imperial gallons, valued in the crude at \$1,099,868. Returns from the refineries are only complete for 21,160,170 gallons; but with the data which these afford it is possible to make a very close estimate of the production of all the refineries. The average of illuminating oil in the crude was 39.12 per cent., at which rate the total of the distilled oil would be 13,322,320 gallons, valued at \$1,372,209. The yield of lubricating oils was 12.45 per cent. of the crude, giving a total of 4,239,847 gallons, valued at \$277,500. All other products except paraffin made up 28.14 per cent. of the crude, or a total of 11,220,705 gallons, valued at \$323,156. The paraffin wax product is computed to be 2,250,000 lb., valued at \$143,325. Besides the above, a produce of the crude was utilized for fuel, the value of which is computed to be \$72,500. The aggregate value of the industry was therefore \$2,188,690, and it gave employment in the refineries to 515 men, whose wage earnings are computed at \$302,000. The number of men employed in other departments has not been ascertained, but the total number employed by the industry is not less than 1,500.

Seventeen firms and companies have made returns of natural gas produc- ^{Natural gas.} tion, but six of these were inoperative for the whole or a greater part of the year. The number of wells bored during the year was 27, of which 19 were producers and 8 non-producers. The whole number of producing wells in the Province was 107, and the total yield of gas is computed to be 2,342,000,000 cubic feet, valued at \$238,200. Eight wells in the Essex field have an estimated daily capacity of 42,000,000 cubic feet. Hitherto these wells have been supplying the villages of Kingsville, Ruthven and Leamington, but an eight-inch pipe line is now being laid to supply Sandwich, Windsor and Walkerville, about 35 miles distant from the wells. Last year there were 117 miles of pipe lines in the Province; the number of working men employed in the industry was 59, and the amount paid for wages, including the cost of labor drilling wells, was \$24,592.

Mining operations were carried on in the county of Hastings, opening up fibrous talc properties in the township of Elzevir, and lithographic properties in Marmora; but although they gave employment to a considerable number ^{Fibrous talc and lithographic stone.} of men, at a cost of several thousand dollars in wages, the work was mainly of a development character, and mineral was not produced in marketable quantity. The results of these operations accordingly cannot be presented in statistical form, but hopes are entertained that the properties are in a position to produce considerable quantities both of fibrous talc and lithographic stone during the present year.

SUMMARY OF MINERAL PRODUCTION.

Product.	Quantity.	Value.	Em- ploye's No.	Wages.
		\$		\$
Dimension stone, cubic feet.....	1,400,000	260,000		
Heads and sills, " " ".....	44,700	21,000	1700	464,000
Coursing stone, square yards.....	170,000	180,000		
Rubble, etc., " cubic yards.	410,000	260,000		
Natural rock cement, barrels.....	74,353	63,567	224	60,208
Portland cement, " " ".....	31,924	63,848		
Lime, " " " bushels.....	2,700,000	364,000	660	122,500
Drain tile, " " " " No.....	17,300,000	190,000		
Common brick, " " " " ".....	162,350,000	932,500	2650	451,000
Pressed brick, plain, " " " " ".....	20,208,000			
Pressed brick, fancy, " " " " ".....	1,373,000			
Roofing tile, " " " " ".....	53,000	217,373	224	80,686
Terra cotta, " " " " ".....				
Sewer pipe, " " " " ".....		230,000	85	34,000
Pottery, " " " " ".....		115,000	150	36,000
Gypsum, " " " " tons.....	2,818	7,363	33	9,220
Alabastine and plastico, " " ".....	140	14,800		
Phosphate of lime, " " " ".....	20	200	4	500
Salt, " " " " ".....	48,450	149,850	210	44,440
Mica, " " " " ".....	70	8,600	40	4,500
Nickel, " " " " ".....	1,642	454,702		
Copper, " " " " ".....	1,431	115,200	495	252,517
Cobalt, " " " " ".....	19	9,400		
Gold ore, " " " " ".....	5,560	32,960	168	49,027
Silver ore, " " " " ".....	500	2,500	5	400
Petroleum, imperial gallons.....	34,055,000			
Illuminating oil, " " " ".....	13,322,320	1,372,209		
Lubricating oil, " " " ".....	4,239,847	277,500		
All other oils, " " " ".....	11,220,705	323,156	515	302,000
Paraffin wax, " " " lb.....	2,250,000	143,325		
Fuel product " " " ".....		72,560		
Natural gas, M cubic feet.....	2,342,000	238,200	59	24,592
Totals		6,120,753	7,162	1,935,590

Quantity and
value of min-
eral produc-
tion in 1893,
with number
of workmen
employed and
amount of
wages paid
for labor.

THE GOLD FIELDS OF ONTARIO.

Once about a quarter of a century ago in Hastings county, and again about ten years ago in the Lake of the Woods region, discoveries of gold, working of mines and milling of ores had encouraged the hope that Ontario might become a gold producing country. But for one cause or another, after much money and labor had been expended upon properties and works, the conclusion appeared to be reached that the right conditions did not exist, or if they did that the energies of those who ventured upon the enterprise were either inadequate or were misguided and misapplied. Past experience however has not persuaded the men of our day that there is not gold in our Province in workable quantities in districts not hitherto explored, nor even that in fields where operations were formerly carried on without success better methods and appliances may not yield profits to those who have the courage to undertake their development with more capital, modern equipment and new modes of treatment. It was remembered perhaps that in the early days of quartz mining in California and elsewhere, with the old-time processes of treatment, more gold went off with the tailings than was caught and saved ; and it was no doubt believed that with the more scientific methods now in use ores might be treated with profit which twenty-five or thirty years ago were thrown into the dump. | It came to be known also that gold was not limited to Hastings county or the Lake of the Woods district, and confidence was felt that in the wide area over which formations which may be gold-bearing extend there is a chance for making valuable discoveries. Interest in prospecting for gold in various parts of the Province began therefore to revive, new discoveries were reported, and in several localities mining and milling operations started to attract notice. Silver mining had enjoyed a long career of prosperity, and the rich and extensive mines of the western States and Territories had enabled their owners to amass great fortunes. But when prices fell below a point at which it was alleged production ceased to be remunerative, the millionaires of the West closed their mines and works, and their employés were left to shift for themselves as best they could. There was also, it may be said, a touch of politics in the turn of affairs in the United States, arising out of the repeal of the Silver Act. Nevertheless it was not long in that country until capital and industry commenced to take hold of gold properties, to explore and work them ; and the same thing happened in Ontario also, after the silver mines of Lake Superior had closed, wherever discoveries of gold were made which seemed to give promise of reward to enterprise. Other causes had also influenced the movement towards an exploiting of gold fields, the most potent of which doubtless was the

Gold mining in Ontario at earlier periods.

Revival of interest in the industry,

and some causes thereof.

Silver mines closed,

of commercial agents and middlemen, no trouble is ever experienced in disposing of gold ; it has only to be deposited in the bank or expressed to the mint, and forthwith there is an end to the anxieties of the producer. Other occupations may afford larger profits, but there are none in which there is less uncertainty in making sales, and none in which the fluctuations of prices are maintained within narrower margins. And so the industry of gold mining will often attract capital and labor when all other industries are in a state of paralysis. It can only be carried on at a loss when the cost of producing a dollar's worth of gold is more than a dollar. Whether it will be profitable in Ontario or not at this third effort to establish it, remains to be proven.

but sureness
of a market
for the pro-
duct.

The renewed interest in prospecting in various localities, the discoveries reported, and the commencement of mining and milling operations on several new tracts, as well as resumption of work after a period of inactivity on the two old ones, suggested the propriety of devoting special attention to our gold fields during the past summer, the results of which are presented below. Two new fields have since come into notice, each of which may possibly prove to be of greater value than any of the ones referred to here. On Rainy Lake gold was discovered upon the American side of the international boundary in the month of August last year, and since then numerous gold-bearing veins have been explored on the Ontario side of the lake and on the Seine and Manitou rivers, the shows of which are so good as to have attracted to the region large numbers of prospectors. Around Lake Wahnapiatae in the eastern part of the Province gold was discovered several years ago, but it is only very recently that ore of much promise has been found there. If the samples shown are any indication of the general character of the ore, the Wahnapiatae country also will merit and reward the attention of the gold-seekers.

Our gold
fields.

In the description of ores and rocks of mining properties in this section of the Report I have in all cases consulted Dr. Coleman, who has this year been appointed Geologist and Mineralogist of the Bureau.

THE SULTANA ISLAND MINES.

Sultana island is on the north shore of Lake of the Woods. In a direct line it is four and one-half miles southeast of Rat Portage ; but the overland route is used only in winter, and even then it is hardly better than a snowshoer's trail. By water the distance is eight miles,—southward through the Narrows between the mainland and Coney island in Rat Portage bay, and the Devil's gap between the mainland and Treaty island on the south side of the bay ; southeastward by groups of small islands to Bare point, a long tongue of land separating Matheson and Bald Indian bays ; and eastward over a stretch of open water and through another group of green islands to the brown and naked Sultana. This is the summer route, and in good weather it may be taken safely and pleasantly in a canoe. But gusts of wind spring up often without warning on Lake of the Woods, and the canoe is then a frail craft in the lumpy waters. Tugboats are not too safe at such times, especially beyond Bare point, where the wind has a long sweep. But usually it is a delightful trip from Rat Portage to Sultana island, for there are many fine

Sultana
island, in
Lake of the
Woods.

bits of scenery. Perhaps none are more picturesque on this beautiful lake than the little bay with darkly wooded shores above Devil's gap, and the narrow gap itself through which the waters of the lake rush swiftly out into Rat Portage bay.

OPHIR MINE LOCATION.

Originally
attached to
the mainland.

Quarry island.

First dis-
covery of gold,
and issue of
patents by the
Dominion
Government.

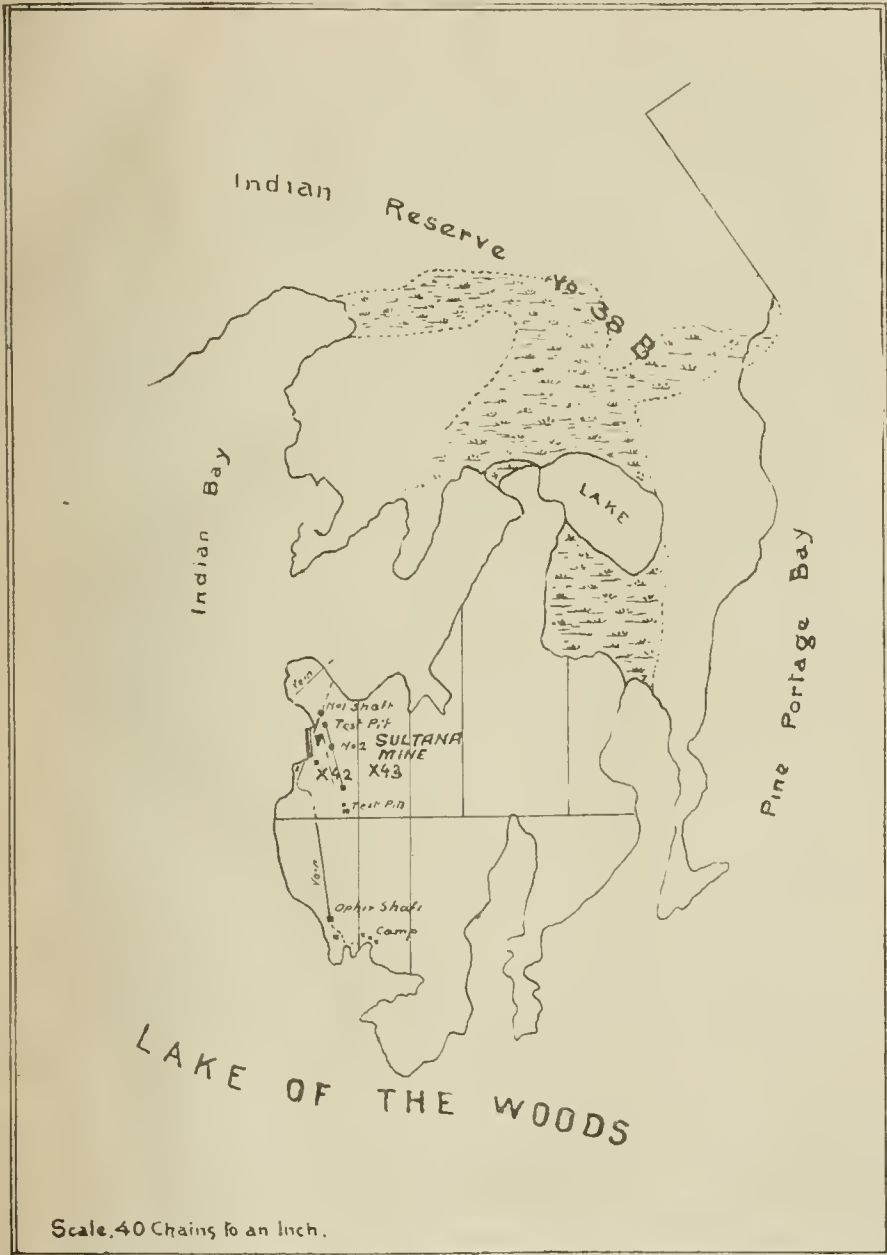
Ophir mine
location.

In a survey and map of Indian Reserve 38B made for the Dominion Government in 1880 what is now known as Sultana island was shown to be part of the mainland, but separated from it by a swamp or marsh. It was included with the Reserve, yet the timber upon it was claimed under the Mather lease (which covered the islands in Lake of the Woods), and in 1880-1 most of the pine on it was cut by the Keewaydin Lumber Company. Six or seven years afterwards, when a dam was built across the middle outlet at Tunnel island, the level of the lake was raised about four feet, and then, if not before, Sultana became an undoubted island. About that time also gold was discovered on the western side of the island, across the channel from the quarry on Quarry island, from which stone was taken for bridge piers on the Canadian Pacific Railway. An intrusive mass of granitic or gneissic rock rises here through the hornblende schists of the district and occupies nearly the whole of Quarry island and a large part of Sultana.¹ Many veins or stringers of quartz intersect this area of gneiss in irregular courses, some of which were discovered to carry free gold. Previous to 1888 applications had been received by the Ontario Department of Crown Lands for mining locations on Sultana island, but before any patents were issued the Department of Indian Affairs asserted its control on the ground that the land was part of Indian Reserve 38B and at the time of the survey was attached to the mainland. The claim was ultimately allowed by the Local Government; but a right of occupation was maintained for several years afterwards by the Keewatin Lumber Company under the provisions of the Mather timber limit lease, and the titles granted by the Dominion Government were under a cloud. The matter was finally settled in November, 1891, and the patentees were left in undisturbed possession by the Lumber Company. But in the meantime the island was overrun by fire, and scarcely a living tree was left upon it. The brown and naked rocks of the west shore now stand out prominently, and the contrast with the green islands in front is striking.

The Ophir mine location, opposite Quarry island, is said to be the first on which gold was found, and specimens taken from it created the impression that it was a very rich property. It is held by the Ontario Mining Company, but a wrangle amongst the officers and shareholders has hindered operations upon it. At one time it was bonded to an English syndicate, and it is said that a shaft was sunk on one of the veins to a depth of fifty feet, with excellent showings, but the wrangle of the shareholders broke out afresh and the ore was thrown back into the shaft, which is now filled with water. There is no

¹ A note on Lawson's map (Geological Survey Report, 1885), referring to this area says: "A boss of coarse grained, gray granitoid gneiss projects through the schists on Quarry island and on the opposite shore. A quarry has been opened in this for material for bridge piers, and the gneiss or 'granite' as it is called, is found to furnish excellent blocks for heavy masonry. Small veins of quartz carrying molybdenite traverse the gneiss in places, and larger veins of molybdenite have been found in the country between Quarry island and Rossland."

doubt that rich ore was found, for although the dump has been picked over by prospectors and visitors many times, fine specimens showing free gold may



2. Map of Sultana Island according to survey of the Department of the Interior in 1880; showing also the plans of mining locations on the island.

yet be got there. I found a number last summer. The vein matter is chiefly a massive milky quartz; some samples are smoky, probably owing to the

presence of hornblende. But what is going to be done with the property, nobody appears to know. The property was patented by the Crown to H. G. McMicken of Winnipeg, 23 July, 1890.

THE SULTANA MINE.

The Sultana
mine location.

Sultana mine, known as location 42x, adjoins the Ophir property on the north, and occupies the whole of the northwestern corner of the island. It is indented on the west and north by small bays, between which a low nose of schistose rock extends out to the northwest, covered with a few feet of rich soil. Along the shore of the west bay the rock is gneiss, the same as on a large part of the Ophir location and on Quarry island. It rises inland in a series of steep benches or terraces to a height of 150 feet above the lake, where it is covered by masses of greenstone. The area of this location is only 27 acres, one-half of which is high rocky tableland, and the remainder low and comparatively level land along the north and west shores. The patent was issued by the Indian Department in November, 1888, to H. Bulmer, jr., J. H. Henesy, C. A. Moore, and S. S. Scovil. In April, 1890, John F. Caldwell of Winnipeg became the owner of all except a sixteenth interest held by Henesy, and this was purchased by him in the fall of 1892. He also acquired location 43x on the east, which had been patented to Messrs. Bulmer and Hart; this has an area of 40 acres. Previously he had purchased an interest in the Ophir, which he still holds. Prospecting was commenced on the Sultana location by Mr. Caldwell in 1890, but actual mining was not begun until March, 1892. The prospecting operations proved that there are at least three veins on the property, one of which runs close to the shore line of the west bay through the low ground a little east of north towards the north bay, and that there are two others along the terraces nearly parallel to the first and probably running into or cutting it before reaching the north shore line, their course being a little west of north. There is evidence of a fourth vein crossing the northwestern part of the location in a northeast and southwest course, but no openings have been made upon it. A fifth skirts the northern shore, showing itself by splashes and lines of quartz at frequent intervals on an east and west course, and is probably a continuation of a large and clearly defined vein which crosses the nose of the promontory between the two bays on the north side of locations 42x and 43x, which is about 10 feet wide and covers the sloping bank down below the water's edge. The vein on the upper terrace is known as No. 1, the one on the lower terrace as No. 2, and the one along the shore as No. 3.

Prospecting
operations.

Principal
veins of the
location.

No. 3.

At the base of a low bluff near the southern extremity of the west bay, No. 3 vein crops out very conspicuously, one side of which is along the water line and the other enclosed by a wall of gneiss. It is a whitish yellow quartz, 23½ feet wide, and quite free from any portion of country rock. Sixty yards south, where the vein might be expected to appear again in a steep projection of the shore line, there are only scattered bands or stringers of quartz from one to six inches wide, but extending over a breadth of 30 feet. On a low beach 150 yards northward it reappears from the bluff of gneiss, but enclosed on either side with a selvage of mica-chlorite schist, the total width of the

vein between the walls of country rock being about 30 feet. At this place the stamp mill has been erected, and in blasting for the foundations large masses of interbanded schist and quartz were thrown out. The vein has been worked by an open cutting some 75 yards beyond the mill, where it appears again to dip under the gneiss. The total width of quartz and schist ranges from 20 to 25 feet, and it is claimed to be free-milling throughout. About four feet of the middle of the vein is a thorough-going quartzite, samples of which furnish a good illustration of stratified quartz, carrying brown oxide of iron and some iron pyrites. The cutting on this vein north of the mill ranged from 12 to 20 feet in depth by 20 to 25 in width, but owing to its nearness to the lake water flowed in so freely through the joints of the rock that work at this point could not be continued to a greater depth without the use of a strong pump.

In the bluff above the most southerly exposure of No. 3 vein, and about 60 yards east of it, No. 2 vein crops out and a cross cutting has been made upon it there to a depth of 25 feet. The course of the vein at this cutting is irregular, and it is not easily traced; but apparently it continues northward through a gap or ravine east of the bay to rise in one of the terraces behind the mill, where it is well defined. There, about 70 yards from the mill and within 15 yards of the open cutting on No. 3 vein, a shaft 6 by 14 feet was sunk last summer to a depth of 30 feet. The vein was found to dip towards the west at an angle of 75° , in silicious gneiss; but a casing of schist lies between the walls and the quartz varying from half an inch to two inches in thickness. At 15 to 18 feet the vein was found to be irregular, but the walls continued to be clearly defined and the character of the quartz to improve. Samples of the selvage taken from the bottom of the shaft consist of fine-grained lustrous mica-chlorite schist, holding crystals of iron pyrites, and samples of the centre of the vein of a purplish quartz with mica chlorite schist and iron pyrites.

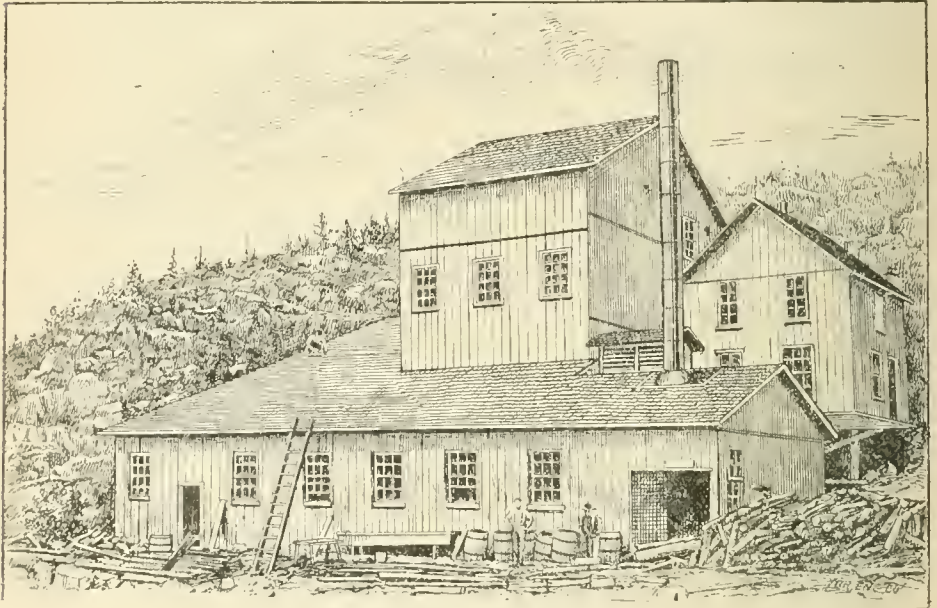
Above No. 2 vein about 50 feet and running in nearly the same course is No. 1 vein, on which a shaft 12 by 7 feet was sunk last summer to a depth of 30 feet. At the surface the quartz matter of the vein is 3 feet wide, with 10 feet of schist on the foot and one inch on the hanging wall, enclosed on both sides with gneiss. The dip of this vein is in the opposite direction from that of No. 2, being about 70° east. Samples of the ore contain pyrrhotite, galena and iron pyrites, the last two predominating, and also some copper pyrites and zincblende. It is claimed that some of the ore from this shaft milled as high as \$300 per ton.

Those three veins gradually approach each other northward, and at a point about 75 yards from the shaft on No. 2 vein a shaft was sunk through the gneiss to a depth of 25 feet in the hope of striking them. Five feet of the bottom of this shaft shows schist and quartz, but in case this should not prove to be the vein proper it was Mr. Caldwell's intention to explore by cross-cuttings. Later in the season however he decided to sink a deep shaft on No. 3 vein at the northern terminus of the open cutting, and by the end of the year he had reached 100 feet. Twelve miners and two blacksmiths,

working by night and day shifts, were able to make rapid progress, and the mill was supplied with good pay ore. Operations were arrested for some time by the flooding of the shaft from the lake, but this was overcome by putting in a pump of sufficient capacity, and work has been continued throughout the winter. At this date the shaft, which is 7 by 14 feet, is down nearly 150 feet, and proves the size of the vein to be well maintained, and the ore of good average quality, it being almost wholly free-milling. By driving levels the supply to the mill has been considerably increased, and the mine is now considered to be on a paying basis. Much of the work hitherto has necessarily been of a prospecting and experimental character.

The mill and
its equipment.

About 200 tons of ore had been taken out of No. 3 vein, where it outcrops on the western bay, to be tested at the Rat Portage reduction works; but no portion of it was satisfactorily milled, and it remained for Mr. Caldwell himself to prove its value by erecting a stamp mill on the location. The mill was commenced on 26th September, 1892, and finished with its equipment of machinery in December. The site as already stated, is close upon No. 3 vein, on the low open space along the west bay. The main building is 65



3. Sultana Gold Mill, on Sultana Island.

feet by 30, raised in terraces against the bluff, with an engine room 20 by 25 feet, and an office building of two and a half stories, 36 feet square. There are two engines, one of 100 h.p., built by the Waterous Engine Works to drive the mill, and one of 8 h.p. built by the Doty Company to run a dynamo. The stamp mill was supplied by the Jenckes Machinery Company of Sherbrooke, but the shoes, dyes, bossheads and tappets are of American manufacture. There are two batteries of five stamps each for reducing the ore, each stamp weighing 850 lb. and running with a drop of six inches at

the rate of 90 per minute.² The aggregate stamping power of the batteries is therefore 382,500 foot pounds per minute, or 275,400 foot tons per day of 24 hours, and this enormous energy results in crushing only 20 tons of ore to a fineness for passing in water through a 40-mesh sieve (*i.e.*, 1,600 meshes per square inch). That is to say, a stamping power of 13,770 foot tons is required to reduce one ton of ore to the condition in which the free gold in it is taken up by quicksilver—a fact which vigorously illustrates the cost of gold-winning. The other machinery of the mill consists of a hoisting drum with steel-wire cable to haul ore from the mine; a Blake crusher, with a capacity of 40 tons per 24 hours; two Tulloch feeders, which feed the ore automatically to the stamps from a 30-ton bin; two improved Frue vanners with corrugated rubber belts, over which the pulp is run to produce concentrates after it has left the amalgamating plates; and a Blake pump to supply water for the batteries and other purposes, the water being pumped out of the lake to a steel tank at the top of the mill. There is also a cyanide plant, which was added last summer, but it is of no practical value, as nearly all the gold in the ore is saved on the plates. The total cost of the mill and plant is about \$30,000.

The stamp mill was started on the 20th of December, 1892, but owing to the poor quality of the dies and other defects it was run irregularly until the 20th of January, when new castings were procured from the States. Work was then continued until the end of April, the gold product being regularly forwarded through the Imperial Bank agency at Rat Portage to the New York branch of the U. S. mint. The mill was closed down during four months of the summer, while the plant for the cyanide process was being set up; but it began to run again in September and has been working steadily since, saving one or two short interruptions.

Mr. Caldwell has met with a full share of the pioneer gold miner's difficulties, but he has faced them with courage, intelligence and enterprise; and while his property has not yet proved to be a bonanza, there appears to be good reason for the hope that it will yield a liberal return. We have not had many miners in Ontario who have shown such tenacity of purpose as Mr. Caldwell, and none who have shown a better example of what pluck and skill can do; and he deserves to succeed.

The employees of the mine and mill last summer consisted of twelve miners, three above and nine under ground, a smith, five mill men and a superintendent, besides two cooks; and the aggregate cost of wages, with board, was about \$30 per day. All employees were housed and fed at the camp, as there was no white man's habitation within several miles of Sultana mine. A part of the location however is finely situated for miners' dwellings, and will likely be used for this purpose. It is level, nearly surrounded by water, and the soil is suited for making excellent vegetable gardens.

² The ten stamps of the batteries strike fifteen blows every second, and the sound made by them is unbroken except to the finest ear. Yet by the arrangement of the cams on the shaft, by which each stamp is raised and turned simultaneously, no two of them drop at the same moment. The agitation of the water in the mortar is consequently as regular as the dropping of the stamps, and the even vibrating flow which carries the crushed ore with it hither and thither over the face of the dies causes it to be reduced to a pulp, the fineness of which is only limited by escape through a screen of woven wire whose meshes number 1,600 per square inch. The native gold in the ore is liberated by this milling process in whole or part, according to the character of the ore and the fineness of the gold, and is amalgamated by the mercury on the inner and outer plates. At the Sultana mill quicksilver is added to each mortar at the rate of one-third to one-half a spoonful every half hour.

THE BURDETTE OR GOLD HILL LOCATIONS.

In the summer of 1885 Mr. D. B. Burdette of Belleville, now of Minneapolis, employed a party of four men to prospect for gold on the east side of Lake of the Woods. The district explored by them lies about twelve miles in a straight line southeast of Rat Portage, having Big Stone bay on the north and Moore bay on the west. The Winnipeg Consolidated mine is on the shore of Big Stone bay, and had been worked to some extent in 1883. Several other gold-bearing veins had also been discovered in the same locality, and eastward of it within a radius of twelve miles, two or three of which are said to be large and well filled with quartz, carrying iron and copper pyrites and some mispickel.³

Winnipeg
Consolidated
mine.

In his description of the Winnipeg Consolidated mine Mr. Coste says the vein was found to be greatly varying in inclination, the dip at the surface being 65° south, at forty feet 57°, at eighty feet 45°, and at ninety feet it was again 65°. "At the depth of eighty-two feet two drifts had been commenced; the western drift was thirty-five feet in length and the eastern twenty-five. The true vein of massive quartz in these drifts as well as in the pit was found to be narrow (6" to 2'); it is certainly auriferous, and I think rich; it contains, besides iron and copper pyrites, mispickel, a little calcite and a very little galena and blende: it follows the foot wall. At the roof the enclosing amphibolite is changed into schist for one or two feet, and these schists are penetrated by small veins of quartz and impregnated with mineral substances; they are taken out and submitted to the stamps in the crushing house, like the quartz. The crushing house is located on the shore of the lake, 500 or 600 feet from the pit; it contains five stamps; a long copper amalgamated retaining plate, a grinder which receives all that passes over the plate and grinds it more finely; and lastly a sort of closed pan, the inner surface of which is also amalgamated so as to retain the last particles of the amalgable gold; the refuse runs into the lake, carrying away all the non-free-milling gold."⁴

The mine here described was closed down in 1884 for want of funds, and the mill is fast becoming a ruin. But the rich specimens of ore taken out of the shaft together with the small quantity of bullion produced at the mill gave rise to a hope that other gold bearing veins might be found in the locality besides those already discovered on the Winnipeg Consolidated and adjoining locations. Mr. Burdette was one of the few inspired to prospect this region of the lake, and he chose for his field of exploration a portion of country about

"A mile and a half east of the Winnipeg Consolidated mine, in the woods, and forming part of the property of that company, is another vein in which a small excavation some ten feet deep has been made. This appears to be a very good fissure, and the vein of quartz filling it is massive; it is quartz mixed with calcite, and is rich in iron and copper pyrites, with a little galena. The thickness of this lode is about five feet; it strikes 165°, and dips east. About a quarter of a mile farther east in the woods, another vein about eleven feet in thickness has been purchased by an American company." E. Coste in *Geo. Sur. Canada*, 1882-4, p. 12K.

⁴ E. Coste in *Geo. Sur. Can.* 1882-4, p. 11K. Mr. Coste might have added that much of the mercury was allowed to run off into the lake also, for if one examines the bottom of the small inlet where the mill stands he will see that it is covered with pellets of mercury. Alexander Matheson of the Hudson Bay Co. stated in his evidence before the Mining Commission that "the mill was not well suited for its work, and the managers had not sufficient knowledge of milling gold ore to make proper use of the equipment they had." It would seem so.

1,000 acres in extent lying two miles south of the Winnipeg Consolidated Co's location, close to the line of contact between the Huronian and Laurentian formations. Moore bay bounds it on the west, and several picturesque lakes lie within its limits. There are two ways of approach to the Burdette territory, one from the landing of rocks at the Winnipeg Consolidated mill and the other from the head of Moore bay, and either way the trail or road is about two miles to the location of the present works. The one most frequently taken however is by the way of Moore bay, from which has been constructed a wagon road and a pole-road—the latter to facilitate the drawing in of heavy machinery required for the mill. Moore bay itself is reached from Big Stone bay through a narrow, winding, beautiful channel known as Eagle Pass, which lies between Hay island and the mainland.

Mr. Burdette's party of explorers consisted of F. W. Moore, Joseph Thompson, J. K. Wright and George Dulmage. These men made a careful survey of the district selected for the purpose during the season of 1885. Several veins were discovered by them, some of which were large and well defined, and almost all of which, it is claimed, showed free gold in the ore or in the pan. Application was made for eight several locations, to which fancy names were given after the manner of miners. One was known as the Ada G., a second as the Combination, a third as Jerusalem, a fourth as Golden Slipper, a fifth as Big Ellen, a sixth as Live Post, a seventh as Judge Mills and the eighth as Golden Gate. All these lie in a block between Moore bay and the line of contact, but owing to the boundary dispute delay occurred in issuing the titles. However in July, 1891, Mr. Burdette obtained patents for six of the locations, covering an area of 458 acres. Four of these, viz.: 190P of 247 acres, 191P of 9 acres, 193P of 14 acres and part of 194P of 52 acres, are included in one patent. The others, 175P of 58 acres and 70K of 78 acres, are held under separate patents. The rest of the area prospected and applied for was in the Mather timber lease, and the title to it is still in the Crown.

THE NORTHERN GOLD COMPANY.

Having acquired his patents, Mr. Burdette proceeded to interest a number of Minneapolis capitalists in his enterprise, and in 1891 the Northern Gold Company was organized under the laws of the State of Michigan and stocked for \$1,250,000. The company acquired forty acres of location 70K, upon which some development work had been done in 1886. Six parallel veins cross this property in a formation of fine-grained mica-chlorite schist. Upon one of these near the northern side of the location, known as the Ada G. vein, a shaft was started in the fall of 1891, eight by ten feet in size, which was sunk to a depth of 50 feet. The vein is six feet wide and dips southerly at an angle of 50°. At 35 feet the dip is said to change to 60° or 65°, but the shaft being half filled with water I was not able to verify this statement. The matrix of the vein is a fine-grained quartz, with some mica-chlorite schist, and it carries copper carbonate. The next vein, known as the D. B., is about 350 feet south of the first. It is four feet wide, and the dip is about the same as the Ada G. Several openings have been made upon it towards the west side of the location, where it is capped with the country rock, and in

1892 a shaft was put down a depth of 50 feet. The third vein lies 45 feet south of the D. B. Like the others, it extends across the location, but is capped at the east and west ends, between which it passes through low ground covered with muskeg. Where it rises to the surface on the west side of the muskeg a trench exposes the vein to a length of 25 feet, and a shaft commenced last summer showed a well defined vein of four and a half feet, dipping southward at an angle of 75°. The ore is quartzite with mica-chlorite schist, the mineralized parts showing copper pyrites and traces of pyrrhetite. Fifty feet farther south is the fourth vein, outcropping two and a half feet wide on the surface; and the fifth vein is 200 feet beyond the fourth, with a width of two feet. The sixth vein is 100 feet south of the mill. At its western end it is covered by the waters of Islet lake, the southwestern boundary of the location, while eastward it is capped with the country rock. A vein having a north and south course has been traced by cuttings from the mill northward, and a shaft has been commenced near the crossing of the D. B. vein, where the formation is mixed and broken. At a depth of 20 feet the vein was struck and some ore taken out. But neither on this vein nor on any of the east and west veins does the ore show visible free gold.

Exploration
work on the
property.

It could hardly be said that real mining work had commenced on this location when I visited it in August. All that had been done to that time had for its object the proving of a number of veins, their extent, and the quality of their ores. Deep sinking would follow, and it was the manager's intention to at once commence such work on the two veins of best promise. One of these is the north and south vein, near the intersection of the D. B. vein. This is known as the No. 3 shaft, and although the formation is much the same as elsewhere on the property—being a fine grained hornblendic chlorite schist, but with more chlorite than hornblende, or possibly an altered trap—it has some time apparently been the scene of considerable disturbance. The ore taken from the shaft is quartzite stained by small quantities of silicate, and mica-chlorite schist with iron pyrites. In some samples very fine grained lustrous chlorite schist is included in the ore, and in others calcite.

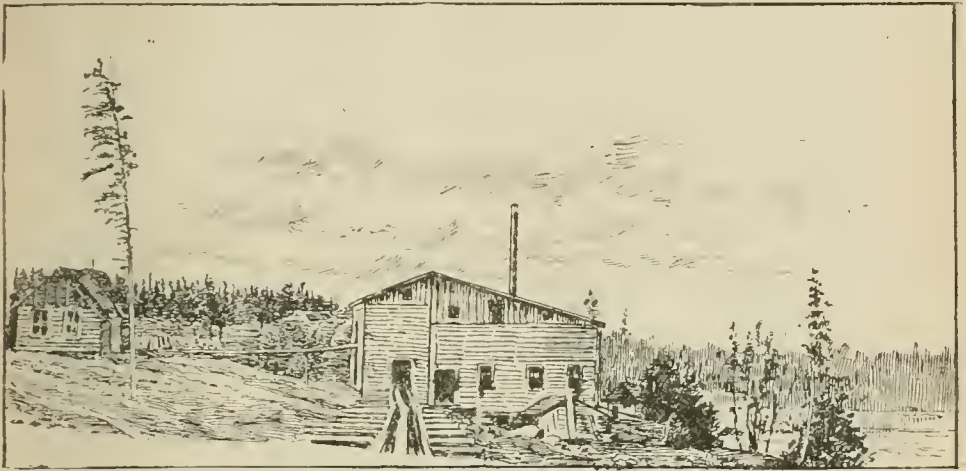
THE COMPANY'S GOLD MILL.

The mill and
its equipment.

In 1892 the directors of the Northern Gold Co. became satisfied that the supply of ore on their location was ample enough to warrant the erection of a mill, and in the fall of that year preparations began to be made for one. The site chosen for it is at the northeast corner of Islet lake, between the rock bank and the water's edge. It is built of jack pine and cedar logs, the dimensions being 30 feet by 60 and three stories high. The basement floor is only half the size of the building. It is occupied with a 45 h.p. boiler and engine, made by Leonard & Son of London, and a set of chrome steel rolls for crushing the ore. The second floor is divided into two rooms, each about 30 feet square, one of which is occupied by a Forster ore breaker, and the other as first fitted up by a Gates pulverizer, a copper stirring tub, a pair of Cook amalgamators and a pair of Leede furnaces for roasting ore. The third floor, which is on a level with the rock bank of the lake, was furnished with a set of steel finishing rolls, two sizers or sieves, and tanks to hold a supply

of water for the boilers and amalgamating tubs, and for fire protection purposes. A small force pump raises the water to these tanks from the lake, and the supply will always be ample for the needs of the mill.

An elevated tramway has been built from the mill to the shaft on the Ada G. vein, over which the ore is delivered from the several shafts to the breaker on the second floor. This machine has a capacity of 65 tons per ten hours, reducing to the size of a four-mesh sieve. From the breaker the ore is lifted by elevators to be fed into sizer No. 1, and the portion of the charge passing through it goes by a spout to the rolls in the basement; the coarser lumps are returned to be fed again into the breaker. In the chrome steel ^{Process of treating the ore.}



4. Northern Gold Company's mill: office and assaying rooms to left, and Islet Lake to right.

rolls the ore is reduced to a twenty-mesh, and is conveyed thence to the finishing rolls on the third floor. Here it is ground to a fineness of fifty-mesh and passes through sizer No. 2, to be reground if necessary in the same rolls. So reduced the charge is conveyed to the copper stirring tub on the second floor, where it is thoroughly mixed with water and discharged over galvanized copper plates for the last process into a pair of Cook amalgamators—quicksilver having been placed both in the stirring-tub and on the plates to take up the free gold.

The Cook amalgamator, an invention of Dr. Henry Cook of Colorado, ^{The Cook amalgamator.} consists of a drum of boiler iron three feet long and twenty inches diameter, with an interior iron spiral having a length of forty feet. One-third of this spiral is silver plated on copper for collection of the floured mercury and fine gold. The drum revolves at a rate of thirty per minute, and the pulp having been carried the whole length of the spiral is delivered on silvered copper plates in which are wells to catch the amalgam. There is no saving of concentrates, if there be any in the pulp, and the water carries the tailings from the last series of plates down a sluice into the lake. The action of the Cook amalgamator, it is claimed, imitates panning. "The circular motion given to the pan," Dr. Cook says, "holds the gangue in such a state of suspension in the water that the mineral is allowed to gravitate to the bottom.

The circular motion of the cylinder accomplishes the same result. To finish separation of the mineral and the fine heavy gangue remaining with it, a small quantity of water is made to flow by a circular motion around the inner edge of the pan, which carries away the fine and heavy particles of gangue, leaving the mineral free, and if mercury is present the particles are all united. The circular action of the cylinder accomplishes the same result." The machine has a capacity of 12 to 15 tons per day of twenty-four hours, weighs 500 lb., requires 18 gallons of water per minute, and is driven by one-eighth horse power.

THE LEEDE ROASTING FURNACE.

Merits of the
Leede furnace
for roasting
ore,

A special feature of the Northern Gold Co's mill as first out-fitted was the Leede furnace, a pair of which were set up for roasting the ore before subjecting it to the rolls. This furnace is the invention of Julius Leede of Minneapolis, and the claim made on its behalf is that it imitates the process of nature in oxidizing the ore and so brings it into a free-milling state. Gas made from crude petroleum supplies fuel for the furnace. In the production of it the oil is fed into a chamber where it is agitated or "atomized" by air blown into it through a set of perforated tubes, in which condition it passes into a retort maintained at red heat and is there converted into gas. The furnace itself consists of an upright cylinder of rolled plate, of two feet diameter and six feet height, divided into an upper and a lower section by a trap diaphragm, and having an inner slitted cylinder of about fifteen inches diameter to hold the ore. The gas is forced out of the retort through tuyeres at the base of each section of the furnace, where it is ignited and the ore is subjected to a flame of intense heat. In the annular space are a series of perforated tubes from which jets of water play upon the ore at short intervals through the slits of the inner cylinder, whereby, according to the idea of the inventor, nature's process is pursued of oxidizing the ore by the combined agencies of heat and moisture, and the sulphur, arsenic and other refractory constituents are carried off in a gaseous state to be recondensed as bye-products in a cooling tank. At the start the upper section of the furnace is filled with ore as it comes from the breaker, and when treated for a certain time the charge is dropped through the trap into the lower section, where it undergoes the process again and becomes converted into free ore, ready for the pulverizer and the amalgamator.

in theory and
practice.

Such is the Leede furnace in theory, with a capacity of roasting 30 tons per day of twenty-four hours. The officers of the Northern Gold Co. had witnessed the performance of an experimental plant set up and tested under the eye of the inventor at Minneapolis, and confidence in its suitability for the work was shown by their ordering two furnaces for the new mill, together with a supply of nearly 200 barrels of crude oil for fuel.

The mill was started on the 23rd of July, but the Leede furnace was a grievous disappointment. The generator could not produce enough gas to roast $3\frac{1}{2}$ tons of ore per day, and after a futile attempt to induce the inventor himself to visit the works and direct the operations, a meeting of the directors was held and orders were given to reconstruct the mill. The Leede plant

was torn out, the pulverizers and sizers were removed, and a ten-stamp mill of the Gilpin county pattern was procured in their stead. But it was near the end of the year before the alterations were completed, and there are no operations to report. The mill reconstructed.

OTHER GOLD HILL PROPERTIES.

A ravine the head of which is in the eastern part of the Northern Gold Co's location runs eastward about half a mile to Granite lake, a small body of water Keystone vein. along the contact line of the Huronian and Laurentian formations. The south bank of the ravine is near the lake a steep cliff of mica-chlorite schist about ninety feet high, and is cut from top to bottom by a vein thirty feet wide, which is known as the Keystone. This vein has a north and south course, dipping about 65° eastward, and consists of white crystalline quartz with fine grained schist and calcite, carrying copper pyrites and films of carbonate of copper. The wall rock appears to be a fine grained chlorite or mica-chlorite schist, which is more or less mixed with the vein matter. A granite dyke eight feet wide cuts across the vein and the country rock, having an east and west course, and about seventy-five yards nearer Granite lake is a quartz vein six to eight feet wide, running north and south. The Keystone vein is traceable across a high ridge about a quarter of a mile south and disappears under marshy ground. Beyond this low land what seems to be the same vein is noticed again and may be followed to the shore of Gold lake on location 190p, a mile from the northern outcropping at Granite lake.

There are a number of veins on location 190p, on two or three of which A series of veins on Gold Lake. some prospecting work has been done. On one of these, the Combination vein, a shaft was sunk by Frank Moore five years ago to a depth of 56 feet, and it is claimed that good samples of ore were taken from it. The vein is seven feet wide, runs northeast and southwest, and dips towards the west. East of it about 300 yards is a parallel vein eight feet wide, and 100 yards farther is what is believed to be the Keystone, seven feet wide. Seventy yards west of the Combination is a decomposed vein three feet wide, having an east and west course, and 100 yards farther on is a like vein eighteen inches wide. All these veins run into Gold lake, a beautiful sheet of water enclosed on all sides with dense greenwood.

There are several other veins on properties explored by Mr. Burdette, one of which on the Judge Mills location is about twenty-five feet wide; but as far as known they do not carry gold.

THE BLACK JACK MINING COMPANY.

Mining location 90x, known as the Bulldog mine, adjoins the property of the Northern Gold Company on the west, while north and west of it are The Bulldog mine. the locations of the Canada Consolidated and the Winnipeg Consolidated Companies. It consists of 336 acres, and the Crown patent was issued in 1889, to William J. Franks of Toronto. Mr. Franks prospected it to the extent of putting down a test pit on a northeast and southwest vein to a depth of 18 feet, which is said to have assayed \$8 to \$14 per ton. In the fall of 1892

Developing
the property.

this location was purchased by the Black Jack Mining Company, composed of Duluth and other Minnesota capitalists, with Parlan Semple of Oshkosh as president, E. Brown of Duluth as secretary-treasurer, and E. B. Barnes as general manager. The Company began operations by putting down a shaft 11 by 7 feet on the southern part of the property, at a point on a bluff about 300 yards north of Islet lake and 100 yards from the eastern line of the lot. The vein lies in hornblende schist, is about 8 feet wide, and is composed of quartz and mica-chlorite schist. Samples of the ore show it to carry copper pyrites and small quantities of pyrrhotite. On the 17th of August the depth of the shaft was 63 feet. It is perpendicular to a depth of 20 feet, and then dips south at an angle of 75°. At 52 feet a drift has been opened east and west on the vein about 18 feet, and a cross cutting 9 feet north and 3 feet south which shows vein matter throughout. At that date mining operations were carried on with a small force and prospecting pits were being sunk on other veins, some of the ore showing free gold. In the winter of 1892-3, a small mill building was erected at the foot of the bluff near the shaft. It is built of round logs, the main portion being 30 feet square, with an engine room 18 by 25 feet, and a crushing room 16 feet square on the bank attached to the main building. It was equipped with a steam engine and boiler of 40 h.p., two Crawford mills, and a Blake crusher with a capacity of breaking 20 tons of ore per day of ten hours to half inch size. Only one of the mills was tried and 50 tons of ore were run through it in a week, but the work was not satisfactory. It is admitted that the free gold was extracted, \$300 having been saved from the run, but that the gold in the sulphurets was not touched. Charles Brent was in charge as superintendent and assayer, with four miners, engineer, teamster, and cook; but I learn that operations were closed early in the fall of the year, owing to the financial stringency in the States. There are numerous veins on the location, and it is probable that the work of developing them will be resumed when money gets easier.

Testing the
ore with a
Crawford
mill.

PINE PORTAGE MINE.

Location of
the Pine Port-
age mine.

A property which made some stir in the Lake of the Woods district ten years ago is known as the Pine Portage mine. It is easily reached from Sul-tana island by paddling up to the head of Pine Portage bay, south of the island, a distance of about three miles, and then following the road towards Rossland about half a mile to the old camp built when operations were active at the mine. A road leads southward from the camp between two ranges of rock which at a distance of 300 yards open out into a spacious valley, with the Huronian schists on one side and the Laurentian granite and gneiss on the other. At the head of this valley the mine was located, and a mill and all other necessary buildings were erected alongside a little stream which has its source not more than 200 yards above. Referring to this enterprise in the Geological Survey report of 1885, Andrew C. Lawson said:

Early records
of the enter-
prise.

"The Pine Portage mine, the most important and most promising venture in the district, was worked steadily throughout the summer of 1884, there being about a dozen hands employed. The shaft was sunk to a depth of 100

feet, and a drift run to a considerable distance to the south. The ore was milled as it was taken from the shaft. In 1885 very little work was done at the mine, but it is, I believe, the intention to continue operations during the coming season, the aspect of the vein and the character of the ore being fairly constant so far as developed, and warranting the vigorous prosecution of the enterprise. The reason assigned for the suspension of work is largely the difficulty encountered on the part of the proprietors in securing a thoroughly competent and experienced mining engineer to take charge of the operations of the mine, and their reluctance in the light of experience to enter upon any further serious outlay till such a manager can be procured. The position taken by the proprietors of the Pine Portage mine is a sound one, but one that brings into prominence the fact that in Canada or the adjoining States there are extremely few practically trained mining men, who, in addition to their knowledge of the economic management of the works and mine, possess also a scientific comprehension of the problems concerned in the extraction of the gold, which will enable them to study to advantage the milling of new ores such as these, and devise methods of treatment for particular cases which will preclude serious loss in the tailings, such as has been the aggravating experience at the Pine Portage mine."³

The course of the vein is a point west of north and east of south, and it has been explored on the surface by an open cut for a length of 50 feet in the walls of hornblende schist, the hanging wall rising about 70 feet above the valley. A shaft sunk at the southern end of the open cut is now filled with water, but it shows a dip of about 75° to the east. Mr. Lawson, who had an opportunity of examining the mine while work upon it was in progress, describes the lead as a fissure cutting a hard massive schistose hornblende rock at a distance of only 150 feet from a granite mass towards which it dips, and as parallel to the contact of granite and schist. "The dip of the Pine Portage vein towards the granite mass at so short a distance to the east of it is a feature of the mine that may develop interesting facts as the work proceeds. It is extremely difficult to discover whether the granite actually occupies an inferior position to the schist, or the reverse. If the former is the case the shaft, if continued at its present incline in the vein, would strike the contact of the schist and granite at no great depth, and the analogy of some of the most successful mines would warrant the presumption of a concentration of metallic material in the neighborhood of the contact of two such diverse rocks, with the juxtaposition of which is so evidently associated the existence of the lead."⁴

But in spite of the seemingly good promise of this property, it has lain idle for the last ten years. One of the principal owners, Mr. Thomas W. Dobie of Tilsonburg, claims to have expended \$25,000 upon it, and his confidence in its value remains unshaken; but others are not so sanguine, and hesitate, it is said, to put up their share of the money required for a thorough development. It would certainly be very interesting to know the character of the vein at the line of contact,—if it continues into the granite and is

³ Geo. Sur. of Canada: Report on the Geology of the Lake of the Woods region, 1885, p. 141 cc.

⁴ Ibid, p. 143 cc.

mineral-bearing in that formation, and if at the contact there is any enrichment of the contents of the vein, as is often found to be the case in such circumstances.

The mill which was built to treat the ore of this mine is already a ruin. It was supplied with a steam engine from Erie City Iron Works, a Fraser and Chalmers stamp mill and a pair of Frue vanners, and these remain as if waiting for the mine to start into life again. But one wonders why such a mill should have been erected on a brooklet whose channel is dry half the year. Obviously enough, and for more reasons than this one, there was need of the service of a competent engineer to manage the affairs of Pine Portage mine.

THE RAJAH MINE.

A mining property in Jaffray township.

English capital interested in it

Extent of mining operations.

The Rajah mine is on location 317P, about five miles northeast of Rat Portage, and consists of 131 acres. By the recent survey of the township of Jaffray it is found to occupy part of lot 13 in the seventh concession of that township. A colonization road intended to connect Rat Portage and Rossland runs about three miles south of the location, from which it is reached by a very good road over a belt of burnt land. The Rajah Gold Company of London, Eng., acquired the property early in 1892 from Messrs McGee, Brereton and Henesy, the joint discoverers, and made arrangements to develop it. Bands of hornblende schist and gneiss cross the location from northeast to southwest, rising to a height of 150 feet above the valley on its western side. The vein runs with the course of these bands, and has been traced about one-third of a mile across the location; but about midway an east and west gorge makes a break in its continuity, which is covered over with debris and soil. At the northern end a shaft 7 by 9 feet has been sunk to a depth of 60 feet. The dip of the vein is about 85° to the northwest, and the hanging wall is well defined from top to bottom of the shaft. At 36 feet a gallery was driven southward on the vein a length of 47 feet from wall to wall, the average width of which was found to be about 5 feet. The ore is a fine-grained quartzite in bands of blue and white, and carries iron pyrites. It is stated that assays made by Mr. Hille of Port Arthur showed an average of \$15 in gold and silver per ton. On the southern side of the gorge a shaft of 7 by 9 feet has been sunk to a depth of 63 feet, and work was in progress at the date of my visit (August 19th). It is mostly hard hornblende schist, containing however a band of quartz which varies in thickness from 3 feet to 10 inches, the latter being its width at the bottom. Assays are claimed to have shown as high as \$200 of gold and silver, but the prospect is not at all promising. At the break in the vein made by the gorge an opening was being made at the time of my visit, and samples of ore taken out showed it to be composed of banded quartzite, with some limonite and tourmaline. A force of nine men was employed, under the management of M. T. Hunter, and operations had been carried on steadily since the first of December, 1892. The London Company sent out an old and experienced expert, Mr. W. B. Pascoe, to examine the property last summer, and he collected many bags of samples to assay upon his return to England. It is understood that Mr. Pascoe's report has been decidedly unfavorable, and that the Company has ceased operations.

THE EL DIVER MINE.

This name is reputed to be an English refinement for hell diver, a bird of that species having been seen on the stream which crosses the property when the prospector made his discovery. The location is $2\frac{1}{4}$ miles north of Rossland station, and due east of the Rajah mine, a portion of it being on lot 16 of the same concession in the township of Jailray; but about two-thirds of it is in the unsurveyed district east of the township. The owners are Mr. J. H. Webster, a lawyer of Cleveland, Ohio, and Mr. E. W. Gaylord of Bristol, Connecticut. It is known as location 351P, and contains 80 acres. The easiest way of reaching it is by boat from the head of Island lake at Rossland—a beautiful sheet of water which overflows into Black Sturgeon lake. Paddling a mile and a half northward a landing is found at the rear of Burnt island, from which an excellent road leads over a tract of gravel to the mining camp. The east side of the location is an obscure gneiss, but towards the north and west it is traversed by a high ridge of hornblende slate, the surface of which shows evidence of glacial planing. There are two northeast and southwest veins in the gneiss, on opposite sides of a creek which runs northward to Black Sturgeon lake, half a mile beyond the location. The gneiss rises in rounded bosses on either side of the creek, and along the line of the veins it is cut by numerous stringers of one to five inches wide. The No. 1 vein, on the east side of the stream, has been sunk upon by a test pit to a depth of 8 feet, where the width is shown to be about three feet. Separated from it only a few feet is a narrow vein of iron ore. Another opening, made about 50 yards northward, has exposed a body of ore containing a variety of minerals. Specimens are found to consist of magnetite, impure pyrites weathering into limonite, and pyrrhotite mixed with a silicate, possibly hornblende or pyroxene. No. 2 vein on the opposite side of the stream, 100 yards northwest, crops out in many narrow stringers across a rounded hill of gneiss, and here a shaft house has been built and a shaft 7 by 9 feet sunk to a depth of 102 feet. This shaft was filled with water, and my information concerning it and all other work done on the property was gleaned from Mr. Gaylord, one of the owners. Both walls are in gneiss and the dip is northwestward about 80°. At the surface, as stated above, there is only a showing of stringers, the vein being capped with the country rock, but at a short distance below it is found to be 7 feet between the walls, and this width is maintained to the bottom with little change. The quartz in the vein pinches and widens irregularly from six inches to 4 feet, but it was found to be continuous. At 70 feet it was lost in the hanging wall, but at 85 feet a cross-cut of 6 feet was made where the vein was again found to be 4 feet wide. The quartz, or rather quartzite, is of a bluish tinge, stained with silicate, and is impregnated with iron pyrites. The wall rock is a coarsely crystalline gneiss.

A mine in the
Laurantian
formation.

Developm^t at
work.

In the winter of 1892-3 an American pulverizer was put in to treat the ore, and also a cloth apron vanner to concentrate the pulp; but the process was not successful, and in the spring of 1893 a Crawford mill was introduced. This mill was started in April and was run four weeks. Mr. Gaylord says it treated the ore very satisfactorily in all respects except as to quantity of work.

Milling the
ore.

The mill
destroyed by
fire.

Instead of milling 8 tons per day of 24 hours as claimed by the manufacturer, it only milled 5 tons. And now comes the curious part of the narrative. On May 31 the mill was cleaned up, and the amalgam was left in an open kettle inside the building. That night the building was destroyed by fire. On examining the contents of the kettle it was discovered that they had been strained, as the total quantity of quicksilver put into the mill was 240 lb., and the quantity after the fire was considerably less than 200 lb. The wonder is that after passing through the fire there should be any of it left. However, according to the statement of Mr. Gaylord, there is no doubt in the mind of the owners that the gold in the amalgam was stolen, and that the mill was fired to hide the theft. The engine which drove the Crawford mill and also the hoisting engine was badly damaged by fire, and mining operations on the El Diver were thenceforth discontinued.

THE TREASURE MINE.

Locations of
the Treasure
mine.

Character of
the veins.

The Treasure mine is on locations 400P and 409P, two miles southwest from Rossland station, comprising 160 acres. It is owned by Messrs. Webster and Angell of Cleveland, who have done considerable prospecting work. There are two strong veins on these properties, each of which has a northeast and southwest course. The country rock is a coarse grained granitoid gneiss, and also felsite, a very fine grained and distinctly laminated light gray rock. No. 1 vein is well exposed on the western bank of a depression or gorge which crosses the locations, and numerous stringers run into it, one of which has yielded many samples showing free gold. The fissure of the main vein at the surface is filled with felsite, and near the top of the bank it divides into two veins, the main one continuing in a southwest course with a width of 6 feet, and the smaller one diverging south-southwest with a width of 2 feet. At a point 40 feet below this divergence (or junction) a shaft of 7 by 9 feet has been sunk to a depth of 60 feet. At a depth of a few feet the felsite gives place to quartzite and interbedded mica-chlorite schist, with a little iron pyrites distributed in thin plates or leaves in the fissures. The vein dips towards the southeast, and as the shaft was sunk perpendicularly the lower portion of it is in the country rock. At 50 feet a cross-cut of 36 feet was made which struck the vein at 6 feet from the shaft, showing a width of 7½ feet of banded quartz and schist. The shaft on No. 2 vein is also 7 by 9 feet, and has been put down to a depth of 50 feet. The characteristics of the vein matter are the same as those of No. 1, but with more iron pyrites. It is lined with a selvage of mica-chlorite schist and sericite schist on the foot wall; the hanging wall was not exposed by the shaft, but the vein towards it was well mineralized.

OTHER LOCATIONS IN LAKE OF THE WOODS DISTRICT.

Bad mine.

There are many other gold locations in the Lake of the Woods district, on some of which a little prospecting work has been done; but most of them are held for a speculative object. Bad mine, 349P, consisting of 40 acres, is three-quarters of a mile south of Rossland; M. M. Holmes of Rat Portage,

is part owner. Test pits sunk upon the vein on this property have yielded very promising samples of ore, nearly all of them showing native gold. Norway mine, 395e, is a mile south of Rossland, and is owned by Messrs. McKellar and Horne of Fort William, and Ross of Rat Portage. The vein on it is 8 feet wide, with a course of northeast and southwest and a dip of 75° towards the southeast. A test pit was sunk upon it last summer to a depth of about 25 feet. On Pipestone Point, south of Hay island, in Lake of the Woods, some work undertaken last summer in the interest of Mr. McMicken of Winnipeg. Some samples showed the ore to consist of quartz with iron pyrites and mispickel; in others the mineral was weathered iron pyrites, but no mispickel.

GOLD REDUCTION WORKS.

In a new mining district like Lake of the Woods, where there is scarcity of capital to undertake mining operations as well as of experience to direct them, one often hears a wish expressed for such help to the industry as a custom mill might afford. With a mill that would treat the ore and extract the gold at a fixed charge or toll per ton, or that would purchase ore from miners on the basis of valuation by sample lots, it is thought that owners of locations on or near the lake would be readily induced to develop and operate them. Certainly a body of navigable water like Lake of the Woods—with hundreds of islands on many of which gold-bearing veins have been discovered, and with bays and inlets ramifying a large area of country, which on the testimony of prospectors is a network of veins and fissures—such a water ought to greatly favor the project of a custom mill, and ensure for it a plentiful supply of ore. But something more than a process of reasoning is required before tangible results are realized. Rat Portage has had its scheme of a reduction mill, which has cost the municipality and a goodly number of its citizens many thousands of dollars, and in the matter of results, carefully calculated upon and sanguinely hoped for, it has been a dead failure. I visited this mill on the 18th of August, 1891, when a short test run was made for the gratification of a few interested visitors, and the notes taken then are here transcribed for the first time.

THE RAT PORTAGE GOLD AND SILVER MILL.

"The Lake of the Woods Gold and Silver Reduction Company was organized in December, 1889, under the laws of the state of Illinois, as the Canadian Milling and Reduction Company, with a capital of \$200,000. Work on the mill was commenced in January, 1890, and in May of the same year the concern was reorganized under an Ontario charter as the Lake of the Woods Gold and Silver Reduction Company, with Robert Linn of Cleveland as president, and Henry J. Powers as manager. At first it was intended to erect the mill on a site near Ross, Brown & Hall's sawmill, in the southern part of the town, and the municipality was induced to promise a bonus of \$10,000 when the mill was completed with a capacity to treat 30 tons of gold and silver ores per day. By a subsequent arrangement however

the site was changed to the north side of Rat Portage bay, on the east side of the main outlet of the lake and convenient to the track of the Canadian Pacific Railway.

The mill

"The mill is a frame structure on a stone foundation, 147 feet north and south by 117 feet east and west, and 57 feet high above the first sill in the main portion, where the elevator and water tank are located. Work has been carried on until the present time, and the mill is not fully completed, owing to the non-delivery of part of the machinery.

and its
equipment
in prospect.

"There are two ore crushers with an aggregate capacity of 8 tons per hour—one known as the American, which treats $3\frac{1}{2}$ tons, and the other as the Blake and Dodge, which treats $4\frac{1}{2}$ tons. One per cent. is taken by an automatic sampler, which goes into a box and is pulverized and assayed separately. This forms the basis of the value of all the ore to the mill and to the producer or miner. The rest of the charge is raised by elevators to hoppers on a floor 40 feet above, to descend through chutes and automatic feeders into two pulverizers, known as the Standard. These are six feet in diameter, and enclose a steel ring of 4 by 5 inches, having a diameter of $5\frac{1}{2}$ feet. Within each ring a muller plate is suspended upon a spindle or upright shaft, forming a movable bottom which may be raised or lowered at will. Resting flat upon each plate are nine rolls of 14 inches diameter by 4 inches face. In motion, the spindle revolves the muller plate, and it in turn drives the rolls by centrifugal force on the ring, against which they revolve in an opposite direction from that of the plate. While the charge of ore is entering the pulverizer from above in regular quantity through the automatic feeder, a supply of water is being delivered under pressure from below through the thin annular space between the plate and the ring. Now the same centrifugal motion which sends the rolls against the steel ring carries the ore in the same direction, and between the two hard surfaces it is gradually reduced to pulp. It cannot escape through the opening between the ring and the plate, being prevented by the upward pressure of water which keeps this space clear; but that pressure in the pulverizer gets to be outward as well as upward in obedience to centrifugal law, and the pulped ore issues through a screen which forms a portion of the enclosing wall of the pulverizer above the steel ring. All fine gold is carried out with the pulp, but grains too heavy to be floated drop through the space between the ring and the plate and are collected in the water chamber below. The screen has a fineness of 640 meshes per square inch, which is thought to be sufficient; but of course a screen of any finer mesh may be used if closer milling is found to be necessary for extracting the precious metal.

The process of
treating the
ore

to extract the
gold or silver.

"The pulp from the pulverizers passes over a series of riffles in which the free gold is caught, and the tailings over concentrating tables, from which the concentrates are conveyed to the hopper of a furnace of three chambers. In the first of these chambers the pulp is dried; in the second it is partially desulphurized, and in the third of highest temperature the remaining sulphur is driven off, and if necessary the charge is chlorinated. From the third chamber it goes to a set of steaming pans, moistened by the addition of water and heated by steam to a temperature of 150° F. In two or three

hours sodium and potassium are added, and afterwards quicksilver, the whole being constantly worked and mixed meanwhile by the action of distributors in the pans. When this operation is finished the pulp is transferred to agitators, where it is diluted with water to five or six times, and is thence drawn off into settlers with escape discharges at top and bottom to divide the rich from the lean—the latter passing over concentrators to catch any particles of fine gold which may float off with it, and the former into clean-up pans to be drained off and put into trays for treatment in the retort, where the quicksilver is volatilized and recondensed in a cooler. The bead is then taken off the retort, the contents of the trays are placed in crucibles, and the gold is melted and cast into bricks.

“Mr. Powers has been employed in mining since 1860 and in the erection and management of reduction works for eighteen years, having put up and operated mills in Colorado, Dakota, Wyoming, Arizona, New Mexico and Mexico.”

Such was the mill on the eve of completion in 1891, when half hour trial runs were made under the direction of Mr. Powers to the delectation of visitors. The following subsequent account of the enterprise was given me last summer by Mr. Charles Brent of the Black Jack Mining Company, who had charge of the mill after the retirement of Mr. Powers :

“The mill was completed in the fall of 1891, and the town paid over its bonus of \$10,000 upon the assurances of a report made by Mr. Walpole Roland of Port Arthur, who had been employed for the purpose by the Council of the municipality. According to this report the mill was declared to be capable of treating $191\frac{1}{2}$ tons of ore per day of twenty-four hours. As a matter of fact the only ore treated at the works under Mr. Powers' management was a lot of 75 tons from the Sultana mine, and 5 tons of concentrates from the Pine Portage mine. The average value of the concentrates was \$80 per ton, but after going through Powers' process of roasting and amalgamation they still assayed \$60 per ton. At the end of November a disagreement took place between the president and the manager of the company and the latter resigned. President Linn ran the works until Christmas, treating the Sultana ore, but he wasted about half the gold. I arrived in Rat Portage on the 20th of December and took hold of the management in the first week of January, 1892, and we ran through another lot of 75 tons of Sultana ore, finishing it about 15th January. I was not able to do better with the mill than my predecessor, and at a meeting of the directors it was decided to put in new concentrators and a chlorination plant. This was done; the mill was remodelled and docks erected at a cost of \$15,000, which brought the total cost to this date up to about \$75,000. Under the Linn and Powers organization shares had been sold to cover the cost of the works, the chief purchasers being residents of Winnipeg and Rat Portage. There was about \$5,000 in the treasury when I took charge, and the balance of \$10,000 was raised by the issue of debentures which were distributed pro rata among the stockholders. The improvements were completed and the mill started again in June, 1892. It was run for two months; but numerous stoppages occurred owing to the breakage of various parts of the pulverizers, until

The expectation and the reality.

Manager Brent's story of the mill in operation.

finally three machines broke down entirely and the works were closed. The concentrates were roasted in a reverberatory furnace and subjected to chlorination, but with very poor results on account of the quantity of metallic iron worn off the pulverizers. Experimental tests had given 90 to 97 per cent. by chlorination, but the largest extraction in actual running was not more than 70 per cent.

"The mill was closed about the end of August and has been idle ever since. It was sold under foreclosure of mortgage in January, 1893, passing into the possession of an American syndicate for \$15,000. The intention is to put in four batteries of twenty stamps and resume operations, but owing to financial distress in the United States the undertaking has been delayed."

CUSTOM MILLS AND SMELTERS IN COLORADO.

The story of the Rat Portage reduction works is only one more instance of the folly of adopting new processes on a large scale before they have been tried and proven on a small one, and unluckily it is usually on new gold fields that new-fangled methods are most readily taken up. But the failure of the attempt to establish a custom mill at Rat Portage does not prove anything against the utility of such a scheme to assist mining enterprise or development. Concerning their operations in Colorado, I obtained the following information from Major Long, who had charge of the Cook amalgamators at the Northern Gold Company's mine last summer :

The lesson of
the enterprise.

Custom stamp
mills and
smelters in
Colorado.

"In all gold camps of Colorado," Major Long said, "custom stamp mills are erected for treating ores, and there are custom smelters at Denver, Pueblo and Leadville, and two at Durango. The stamp mills range from 80 to 125 stamps per mill, with a daily capacity of $1\frac{1}{2}$ tons of ore per stamp. They are owned by companies, and as a rule a company owns only one mill. State aid is never given to a mill, neither is municipal aid; occasionally a municipality will give a site for a smelter, but very rarely a bonus. The state requires smelters and mills to keep a record of results, and this record is open to public examination. Every company is obliged to keep a record showing yield, whether it treats its own or custom ores, so that statistics of production may be obtained for public use. In stamp mills the practice is to charge for crushing, usually \$15 per cord of eight tons. The free gold is caught on coppers, and the concentrates are dried, sacked and loaded on cars. Few miners have their own mills, the practice being to send the ore to custom mills. Often also the owner or owners of a mine will let workings under tribute, taking a royalty on the output. The advantages of the custom mill plan are that great care is exercised in the works, that good workmen are employed, that less capital is required, and that each mill aims to do its best possible work so as to secure custom. The concentrates and rich ores are sent to sampling works where they are sampled for the smelters. One lot goes to the assayer of each smelter and one to the owner, who, if he so desires has it assayed by a private or a State assayer—the report of the latter always governing the value in case of dispute. The smelting charge ranges from \$6 to \$22 per ton of ores or concentrates, which is deducted from the price paid for them. The bullion is never returned to the miner, but the value of it is placed to his credit."

THE OPHIR MINE IN GALBRAITH.

Ophir mine in the township of Galbraith is reached by way of Bruce Mines, a station on the Canadian Pacific Railway 449 miles from Toronto, or by railway and steamship via Collingwood or Owen Sound direct to Bruce Mines, or by way of Sault Ste Marie, according as one takes the Northern Transportation or the Canadian Pacific Railway line of boats up Lake Huron.

THE OLD BRUCE COPPER MINES.

The village of Bruce Mines lies on the lake shore, upon a bay between Eagle Point and French Islands; and it is noted for having been at one time the most famous mining centre in Canada. The copper lodes which cut a wide band of greenstone here on the Cuthbertson mining location were worked from 1849 to 1875, and the ore was either smelted on the ground or was crushed and treated for shipment. The principal vein has a northwest and southeast course, extending from the lake shore east of the old village of Bruce Mines for a mile and a half or two miles northwestward across the whole breadth of the greenstone outcropping.

Copper lodes at the Bruce and Wellington mines.

The workings towards the east end were known as the Bruce mines, and those towards the west as the Wellington mines; but several smaller veins occur on both locations, from which considerable quantities of ore have been raised. Shafts were sunk at various points along the veins, some of which reached a depth of 80 fathoms, and in places the ore was stoped out to the surface. Where this was done the openings were covered over with timber and earth or rock for the safety and comfort of the miners; but the timbers are rotted and long sections of the roof have fallen in, showing gaps once filled with vein matter and now filled to 25 or 30 feet of the top with rock and debris. The irregularity of the veins is clearly exposed, as regards both size and course. The width varies from 3 or 4 to 8, 10 and 12 feet or more, and although a general course is maintained it is in places zigzag to a striking degree.

Old workings.

At the old mines a small mill for treating the ore had been erected about 150 yards from the shore, but old miners tell that it fell as soon as the works were started and that three men were buried under the ruins. It was built of the boulders which so thickly strew the ground over the greenstone ridge, and looking at the remains one cannot but wonder what caused walls of such massive thickness to give way. The second mill, also of stone, was erected south of the first and close to the lake shore. The main building is yet intact, but the addition which contained the crushing machinery is unroofed and a portion of the wall upon the west side has fallen. Two sets of Cornish rolls were worked here, into which the ore was fed by a large wooden wheel with wooden buckets on the inner rim, and after being crushed to the requisite size it was jigged to separate the ore from the quartz and other gangue matter of the vein. The jigs occupied a long frame building which stood on the west side of the crushing mill, and were worked over a series of oblong pits, $2\frac{1}{2}$ by 6 feet. They were constructed of coarse wire, about 9 meshes per square inch, and as they were shaken to and fro the ore sank to

Mills for treating the ore.

First mill.

Second mill and smelter

the bottom and dropt into the pit, the lighter gangue matter being meantime skimmed off the top. One boy could attend three jigs. The ore was afterwards removed from the pits and wheeled into a heap upon a platform south of the building, whence it was either taken to the smelter or loaded upon vessels for shipment to Wales. The engine which drove the machinery of this mill is yet standing in the main building. It is of the old Watt pattern, with a huge walking-beam 28 feet in length, and two balance wheels with massive rims of cast iron and a diameter of about 30 feet. A large and well constructed frame building stands upon the east side of the stone mill, which is known as the Yankee mill. It was erected for the purpose of testing an American method of treating the ores, but tradition says it ran only a few days. The manager of the works fell one night from the upper story to the ground floor and was killed, and probably this fatality had much to do with the failure of the process. The smelter stood on the lake shore, about 50 yards west of the mill. It ran for a number of years, but was partially wrecked in a gale of wind and afterwards destroyed by fire.

A sand bar of tailings.

The dump of tailings was on the lake side of the mill, but the waves have washed it into a sand bar which extends out to Crocket's island, about 200 yards from the shore. It is an evidence of the large quantity of ore treated at this mill.

The old village of Bruce Mines.

The old village was a busy place forty years ago, its principal street extending for half a mile along the shore of the lake. The dwellings were either log or frame, and most of them were small, being not more than 20 by 25 feet. All are deserted now, save one. Eastward of the mill stood a row of frame houses, including the Company's store and offices and a number of double dwellings, in front of which ran a well-paved street, now grown over with grass. At the eastern end of this street was the manager's house, which was the most imposing dwelling in the village. Numbers of the old houses have either fallen or have been torn down for fuel. One of these had served the double purpose of a church and a Sunday School.⁵ A union church was subsequently built in the west end of the village, where service was conducted by Episcopalians, Presbyterians and Methodists; but it is deserted now. There was also a small Roman Catholic church in the place, which was moved west after the closing down of the old works, and it too has been unoccupied for many years. The best preserved buildings are the powder houses, which stand apart at some distance northeastward of the mines.

Mills at the Wellington mines.

The Wellington mines were supposed to be much richer than the Bruce, and were worked for nearly twenty years later. The principal openings are believed to be on the same vein as the Bruce mines, but large quantities of ore were taken from another vein farther south, about 200 yards from the lake shore. A small stone mill was built near this latter vein, and a larger frame one about half a mile to the northwest. A third mill of much greater dimensions was erected in 1872 or 1873 a short distance west of the old mill, in the centre of the new village of Bruce Mines. It is about 100 feet by 250,

⁵ The site of this edifice was pointed out to me by Sam Cullis, who said he had attended Sunday School there when a little boy. He passed through all the stages of a miner's occupation at the Bruce and Wellington mines, from jigger-boy to hammer-man.

and its tall brick shaft is a land mark for miles out upon Lake Huron and up the St. Mary river.

The ore was crushed in Cornish rolls at the new mill, as in each of the Machinery of other mills, and the steam engine was of the same design as that of the old the new mill. Bruce mill, though not so ponderous; its walking beam is 25 feet in length. The boilers were made in Lancashire, England, and bear the date of 1871. At that time there were many works in Canada which manufactured engines and boilers of any required capacity, but no doubt the English company was persuaded that they could not compare with the ones made in England for the purpose; certainly they did not in avoirdupois.

A new process, the invention of a Frenchman, was introduced at this mill How the ore was treated. during the later years of its working, by which the milled ore was roasted in brick furnaces, ten in number, and leached in wooden vats which stood in double rows under the low leanto roof on the south side of the building. Certain chemicals were used in the leaching vats, but the cost of the process was so great that the company is said to have lost \$100,000 in one year. The brown colored tailings on the dump indicate the quantity of ore treated by this method.

The great heaps of gray and brown tailings which surround the mill eastward and westward are some evidence of the extent of operations at the Bruce and Wellington mines; yet the piles now remaining here are but a small portion of the whole, as hundreds of train loads have been carried off to ballast the track of the Canadian Pacific Railway. It is currently reported that these tailings carry gold, and that several recent assays show it to run from \$2 to \$7 per ton. It is also said that one or two parties have been anxious to purchase the heap with the object of setting up a plant to extract the gold, but that the railway company thinks it has more value for ballast. A well founded tradition says that the presence of gold in the Bruce and Wellington locations was known to one or two of the old miners. William C. Dobie, police magistrate of Port Arthur, has informed me that it was discovered by his father-in-law in one or more veins, and that he had reported the fact in a letter to the head office of the company, and that for his pains in so doing he was advised to mind his proper business. The discovery of gold in the township of Galbraith was therefore not a startling surprise to some of the old employés of the Bruce and Wellington mines. Gold in the tailings. An early discovery of gold ore.

THE OPHIR GOLD MINE.

From Bruce Mines to the Ophir Mine the distance is usually computed at 16 miles, but as measured by the length of telephone wire put up on the road last summer it is found to be 18 miles. It is an old colonization road, on which many of the employés of the copper mines and their descendants have settled as farmers, and it traverses a number of rich sections of farm land especially around the lake basins and along the river valleys. After running in a northeasterly direction about $3\frac{1}{2}$ miles across the Cuthbertson location, a tract of 6,400 acres, the road cuts through the northwest corner of lot 4 in the sixth concession of Plummer Additional, and thence through lot 4 in the first concession of Plummer to Ottertail, a hamlet at the lower end of a lake From Bruce Mines to Galbraith

of that name where the Thessalon river issues on its way southeastward between high hills of red and white quartzite towards Lake Huron. Winding around the south end of Ottertail lake, the waters of which have been lowered for the purpose, the road crosses a wide peaty bottom and ascends a band of white quartzite hills to trend northward along the line between lots 2 and 3 in Plummer to Coffin, and thence eastward and northward to the townline between Coffin and Galbraith, where once more it enters the valley of the upper Thessalon, near the junction of its east and west branches. Turning south on a newly built road across the east branch, half a mile brings us to the Ophir location. This is composed of the south half of the north half and the north half of the south half of lot 12 in the third concession of Galbraith, having an area as was supposed of 153 acres.

Improving
the road to
Ophir Mine.

The road as far as Ottertail has long been in excellent condition, but beyond that hamlet it was until last year very rough and heavy for the greater part of the way and badly cut up by traffic to and from the lumber camps upon the head waters of the Thessalon, Echo and Mississauga rivers. Little or no statute labor had been put upon it by the settlers since the time of its early construction because, as they claimed, the lumbermen did most of the travel over it and contributed nothing for its maintenance. But with the development of the Ophir mine repairs became a necessity, as in the old state it would have been impossible to carry in the supplies and machinery required at the camp. Accordingly the Ophir Company undertook upon its own account to make the improvements called for by the condition of the road, and \$2,000 was expended in making the worst sections passable. This with a grant of \$1,200 by the Ontario Government has sufficed to put the road in substantial shape, and until the heavy October rains began to fall it was as good for wheeling as many roads in the older settlements. The successive ranges of rocky hills which cross the country, usually in a southeast and northwest course, but in places with awkward irregularity, make steep and long grades unavoidable, but inasmuch as no road allowances have been laid out in the survey, five per cent. of the land being reserved by the Crown for this purpose, the most feasible routes consistent with a general course along the surveyed lines are taken for road construction. The abundance of gravel beyond the Thessalon river furnishes material for excellent road building; and although level roadways are unattainable, it is quite practicable to make them first class in every other respect.

Geological
relations of
the district.

In its geological relations this section of country is one of the most interesting in Ontario. The junction of the Silurian and Huronian systems takes place in the channel between St. Joseph's island and the mainland at Bruce Mines; and after crossing the band of greenstone at the latter place, the breadth of which is not more than a mile, we travel for a distance of not less than 15 miles over a series of formations which fold over each other in long succession to form what is known as the Thessalon trough—appearing, disappearing and reappearing in almost bewildering confusion to one who has not ample time to observe and study out their varied and interesting relations. And what adds to the perplexity of the task is the fact that some time in the long history of the Huronian age a dislocation occurred, whereby the forma-

tions were thrown for thousands of feet out of the lines in which they had been originally laid down. Murray estimated the total displacement at 11,000 feet, and his observations led him to believe that the line of fault extends a distance of about 40 miles, or from near Echo lake to the mouth of Mississaga river.⁶ Then again the crowns of the anticlinals have been planed down by glacial action, filling the valleys to great depths with sand, gravel and clay, while at longer or shorter intervals the formations are cut by dykes of greenstone or upheaved and contorted by mountain masses of syenite and diorite. Little wonder therefore if the geology of the country cannot be read with exactness or satisfaction in the course of a hurried drive across it, however watchful the observer may be.

Between Bruce Mines and Ottertail there are exposures of greenstone, limestone, sandstone, conglomerate and red quartzite; but farther north on the same side of the Thessalon river there are ranges of jasper conglomerate fine grained sandstone, chert and white quartzite. Beyond the river the road passes over successive ranges of white quartzite, red quartzite banded with quartz and jasper conglomerate, white quartzite with bands of quartz conglomerate, red quartzite, altered sandstone containing pebbles of granite and quartz, greenstone and quartz syenite. The last named range is succeeded northward by another outcropping of white quartzite which extends from the schoolhouse in Coffin to the low mountain of gray diorite which crosses the middle of the Ophir location on a northwest and southeast course. About a mile southward, on the farm of Mr. Moor, the quartzite and diorite abut conspicuously against each other, as they also do upon a lower spur at the north-western corner of the Ophir lot. The diorite escarpment is seen to extend for some distance towards the east, where it rises about 300 feet above the bed of the Thessalon river.

Rock exposures en route to Ophir mine.

Nestled on top of the tableland thus formed, and enclosed by high walls of rock saving on its southeast side, is Lake Ickta, three-fourths of whose area of 65 acres lies within the limits of the Ophir location, but without forming any part of it. It is a beautiful sheet of clear blue water, 300 feet in depth, and is fed by numerous springs, a portion of the bottom at the south and southeast shores being quicksand. The outlet at one time was probably on the southeast side, where the beach is sandy and a valley opens out through the mountain; but now it discharges a small stream through a gap in the rocks at its northwestern angle, the waters of which tumble down a narrow gorge until they reach the eastern branch of the Thessalon. There is evidence however that the discharge was through another gorge about 50 yards farther west, when the level of the lake was a few feet higher than it now is, but both channels unite midway down the bluff.

Lake Ickta.

At the foot, where the water of the stream flows off quietly to the river, a quartz vein occurs upon which a shaft has been sunk to a depth of 50 feet, I was told, but it is filled with water. This is on an adjoining location to the Ophir, the northern quarter of lot 12. Openings have been made at various points higher up the bluff, by which the vein may be traced eastward

Veins around Lake Ickta.

⁶It would not be a surprise if this fault was found in sections to be filled with mineral-bearing vein matter; but being covered with drift along the greater part of its length, no attempt to explore it appears yet to have been made.

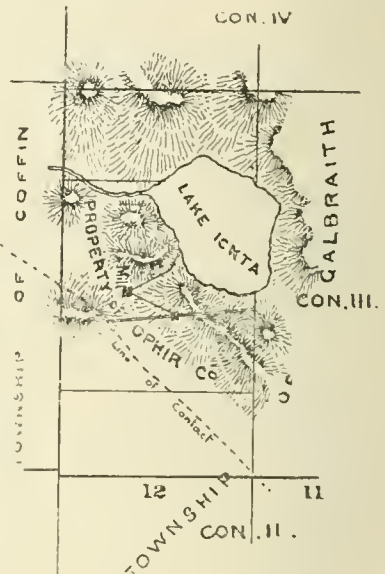
through diorite to what looks like a horse of white quartzite, at an elevation of 100 feet above the shaft, and there all trace of it disappears under the mass of boulders which have fallen into the gorge. Eastward from the outlet of the lake about 75 yards, another vein of chloritic schist and quartz crops out at the waterline and is seen to extend in an easterly direction in the bed of the lake. There can be but a small portion of this vein on the Ophir location however, as the northern limit is only a few yards back from the shore; nor is it known to hold any valuable mineral. A vein of quartzite cuts the diorite for some distance eastward along the north shore of the lake, where the rocks show signs of not a little disturbance.

The Ophir location,

Lot 12 in the third concession of Galbraith was computed in the original survey to contain 320 acres, whereof 307 acres was land and 13 acres water. A survey by Mr. Cozens, P.L.S., shows it to contain 324 acres, whereof 271½ acres is land and 52½ acres water. The total area of the lake is 65 acres, the balance of 12½ acres being in lot 11.

and the discovery of gold upon it.

The discovery of gold on lot 12 is said to have been made by William Moor, a neighboring farmer, but there are so many conflicting stories as to the discovery and the subsequent dealings with the lot that one may despair of getting a statement of facts upon which all the parties concerned will agree.⁷ The portion known as the Ophir location, comprising the south half of the north half and the north half of the south half, was assumed to contain 153½ acres, but according to the Cozens' survey it embraces only 137½ acres.

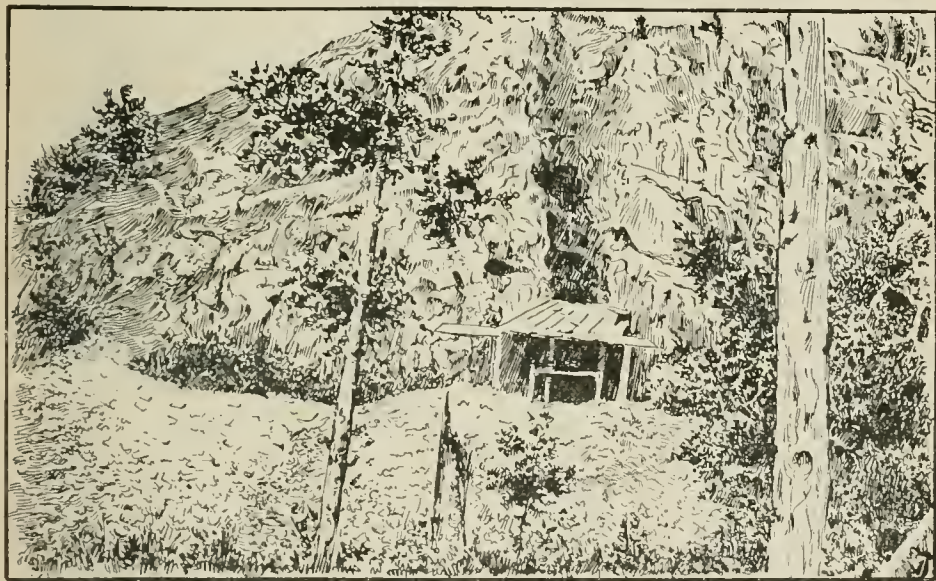


5. Ophir gold location.

⁷ The south half of the lot was purchased by Roderick Mackenzie from the Crown in 1883, at 20 cents per acre, subject to settlement duties. Mr. Mackenzie never lived upon it, but it was claimed that a portion of the duties was performed by his brother. As to the discovery of gold, the following affidavit is filed with the papers in the Crown Lands Department: "I, William Moor, upon oath declare that I live upon the north half of lot 11, con. 2, Galbraith township. That in the month of November, 1889, about the first, while prospecting, I found on the south half lot 12, con. 3, Galbraith township, specimens of ore containing silver ore or lead and gold. That I afterwards showed specimens to a man named Malcolm McLeod and gave him some of them, and they found their way into the hands of a man named W. J. Miller, residing in Thessalon, who came to me on the 12th November and asked me to show him the vein, which I did. He said he thought the discovery was valuable. He said he would open and work the same and pay all expenses and that I should have one-quarter interest, free and clear. I have worked between six and seven weeks on the lot under Miller's orders up to the 22nd day of January, and received seven dollars only from McLeod for same." Sworn before John F. Day at Ottertail, 4th February, 1890. This was filed in the Department by Moor to protect his own interests. Subsequently a similar affidavit by Moor, setting forth original discovery by him, was filed by Miller in proof of claim to the lot. On 7th December, 1889, Miller had applied to purchase the north half of 12 as mining land, and on the 17th he applied to purchase the north half of south half and the south half of north half. He obtained the patent for the north half of the lot, but the ruling in respect of the south half was in favor of Mackenzie, who transferred his interest in the north half of it to Alexander McArthur of Toronto. By a subsequent arrangement the McArthur and Miller interests were united.

Nearly the whole of Lake Ickta lies within its boundaries, occupying the northeastern quarter, but the lake has been reserved by the Crown. The mountain of diorite which encircles the lake shows a perpendicular bluff at the northern boundary of the lot, and extends in a southeasterly direction across it, throwing out a spur westward about midway in which the vein occurs. Another lower boss of diorite outcrops west of the bluff, where it comes into contact with the white quartzite formation, but the rest of the location is for the most part covered with rich black loam to the western boundary, which is the townline between Galbraith and Coffin.

Where the vein has been worked it lies about 100 feet south of the dividing line between the north and south halves of the location, and has a course ^{The vein and its workings².} 15° south of west and north of east. The face of the spur looking westward is cleft from top to base by the vein, showing a dip southward of about 80°. Along the crown or apex of the spur the fissure is traceable eastward 175 feet, where it is covered over by gravel drift. Its width in this distance increases from 18 inches to 7 feet, and the vein matter changes from chloritic



6. Ophir gold mine; showing fissure vein in face of the bluff, and mouth of the shaft; hanging wall of chimney on extreme left.

schist to quartz. On the western face of the spur the vein has a perpendicular exposure of 98 feet from the crown to the base, and it widens from 18 inches to 3 feet 4 inches, being filled throughout with chloritic schist. Here a shaft 6 by 8 feet has been sunk upon it to a depth of 90 feet, and at 85 feet it was found that the schist had given place to quartz in the vein. At the mouth of this shaft the vein is covered with gravel drift to a depth of 20 feet, but its course westward has been exposed by pits a distance of 1,185 feet to the line of contact between the diorite and the white quartzite, where it ap-

pears to be broken into stringers. A pit sunk in the drift at 1,000 feet shows it to be $3\frac{1}{2}$ feet wide. On the northern slope of the spur there is very large outcropping or chimney of vein matter, extending around it like an arc of a circle. It is divided into three lens-shaped folds by bands of schist, whose greatest thickness is 43 feet. The workings show it to be connected with the fissure vein at both ends of the arc, its total length being about 400 feet. The point of junction at the lower or western end has not been definitely ascertained, but it is probably not more than 100 feet west of a vertical line from the base of the spur; the upper or eastern junction is shown by an adit to be about 225 feet from the nose of the spur. The upper and middle folds taper and run out towards the east, and an incline shaft 6 feet square sunk upon the lower part of it, 75 feet from the shaft upon the fissure vein, proves that they run out downwards also. The depth of this shaft is 105 feet, and being sunk upon the foot wall the dip is shown to be 40° south. This is maintained to 65 feet, when it changes to 50° , and it is at this point that the upper and middle folds thin out; it does not appear however that they are gold-bearing anywhere. The pay streak is in the lower fold, but it varies greatly; in some places the mineralized portion is not more than 4 feet wide, in others it is 16 feet, and in some sections the vein is barren. Four adits have been driven in upon the chimney at intervals above the incline shaft, the level of the fourth or top one being 115 feet above the mouth of the shaft. The first has a length of 80 feet, its course being 5° north of east. The second is 25° degrees south of east and has been opened to the roof; the vein has been worked out from wall to wall and has a thickness of 43 feet, and discloses a long wedge-shaped horse of diorite between the folds. Between the top of the chimney vein at this point and the fissure vein on the crown of the spur the thickness of country rock is 85 feet, and this apparently forms the hanging wall of one vein and the footwall of the other. The third adit is 75 feet, on a course 10° south of the east, and has been stope out overhead 27 feet; its mouth is at the end of the upper and middle folds of the vein, and is 100 feet east of the opening of the second adit. At the mouth of the fourth adit the chimney and fissure vein join, and the quartz at this point is rich in free gold. This adit has a course 5° south of east; it has been driven in a length of 75 feet, and by a cross-cutting at 60 feet the vein is shown to be $16\frac{1}{2}$ feet in thickness.

A record of operations.

Serious mining work was not undertaken upon the Ophir location until October of 1892. A number of shallow pits had been sunk upon the chimney vein, and at the lower end of it a shaft had been put down 10 feet. The owners had given an option on the property to a concern known as the International Development Company of Duluth, which also held options on several other properties in the district; but no work was done by it. A Chicago syndicate had been doing exploratory work on an adjoining property during the year, and it is stated that \$25,000 was expended in sinking test pits in the drift with the object of discovering an extension of the Ophir vein towards the northwest, in the fond belief that it connected with a vein discovered $3\frac{1}{2}$ miles distant, then called the Mudge property, but now called the Tiptop mine. Several pits were opened to a depth of 75 feet, but no vein was discovered

there; the course of the Ophir vein, as was afterwards proven by Colonel Wallace, was nearly due west. But the operations of the Chicago syndicate served to keep alive the interest in the locality, and the Development Company induced a Duluth syndicate with A. E. Humphreys of that city at its head, to look after the Ophir. Mr. Humphreys was a successful lumberman, with no experience of mining affairs, but having with his associates been fortunate enough to secure the service of an old and intelligent miner in the person of Col. W. R. Wallace—who had discovered for them a valuable iron ore property on the Mesabi range in Minnesota—they were encouraged to find out what the Ophir location was worth. Colonel Wallace was sent to examine it in September, and his report being favorable the Ophir Company was organized to purchase the property for \$100,000. Among those associated with Mr. Humphreys were George J. Atkins of Duluth, Frank Woodman of Charleston, W. Va., and George E. Milligan, then of Duluth but now of Chicago. On the 5th of October Colonel Wallace came to take charge of the development work as superintendent, when arrangements were made to clear off the land and erect the necessary buildings. Supplies were procured and mining operations commenced, the men boarding with farmers in the neighborhood until a boarding-house was completed on the 10th of November. Other buildings were constructed, including a dwelling for the superintendent; and as accommodations were increased additions were made to the force of miners and workmen. Nearly all the timber on the lot was cut down and cleared off, offices, dining hall, blacksmith's shop, etc., were built, and work on the fissure vein and chimney shafts was commenced and carried on throughout the winter. But when the spring thaw came on the shafts filled with water, and as no pumps were provided the superintendent set his men at work to open the higher section of the chimney vein by driving adits into it. In this way a large pile of ore was brought to the surface, and preparations were commenced for building a stamp mill.

The contract for the mill was let to Messrs. Fraser and Ohalmers of Chicago; but the excavations were made under direction of the superintendent, who also procured all necessary supplies of timber and lumber. Excavation work was commenced about the 20th of July, and the mill was started on the 9th of October. The main building is 58 by 81 feet, five stories high, with a wing of 37 by 46 feet for engines and boilers. The vanners floor, upon which are eight Frue vanners, is 37 by 58 feet, and 13 feet high; the battery floor, upon which are four batteries of five stamps each, is 37 by 58 feet, and 11 feet high; and the ore-bin and rock-breaker floor is 7 by 58 feet. A tramway from the latter floor connects with the ore-pile at the mouth of the first adit of the mine, and the ore is conveyed over it in iron cars by gravitation. The engine is a Reynolds-Corlis, built by John Doty & Co. of Toronto, and is 75 h p. Steam is supplied by two boilers of 120 h.p., which will also supply power for the mining machinery when required. The stamps weigh 850 lb. each; they are run at 85 per minute with a drop of only five inches, as the ore is easily crushed. The effective power of the four batteries is therefore 602,083 $\frac{1}{3}$ foot pounds per minute, or 433,500 foot tons per day of 24 hours; and as the stamping capacity of the mill is 40 tons of ore per day, the power required to

The stamp mill and its equipment.

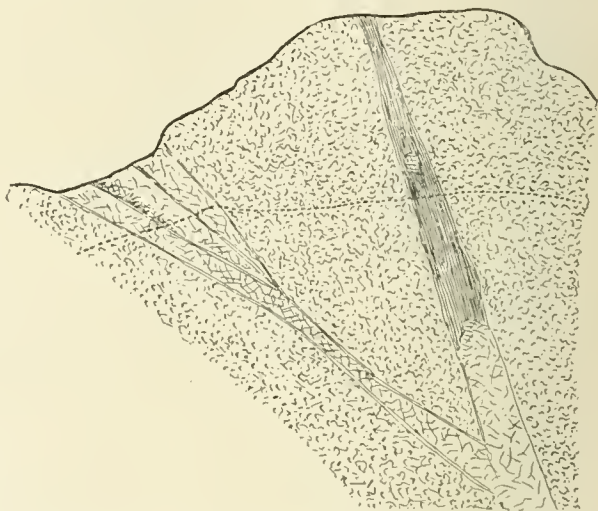
Its working capacity.

crush one ton to the required fineness for extracting the gold is $10,837\frac{1}{2}$ foot tons, or the equivalent of 61,200 stamp blows. Quicksilver collects the free gold in the batteries, on the plates, and in riffles on the vanners; the sulphurets, which carry gold, are saved and concentrated by the vanners for subsequent treatment, and it is claimed that not more than 50 cents of gold per ton is lost in the tailings. One battery of stamps was started on 9th October, and by the 14th the mill was in full running order.

Water supply. Water for the boilers and batteries is supplied from Lake Ickta, through a four-inch pipe 1,100 feet long. A No. 4 Blake pump, driven by a 10 h.p. boiler, lifts the water from the lake over a bank 46 feet above its level, from which there is a fall of 164 feet to a tank at the mill. Here it is warmed by exhaust steam from the engine, and is therefore of suitable temperature for the batteries in the coldest weather. The main pipe also delivers an ample supply of water for domestic uses in the camp.

Condition of the mill and mine as regards safety and health.

My first visit to the Ophir mine was made early in the month of September, when the mill was in course of construction. I returned again in October, a week after the work had started. I found all parts of the mill to be in safe condition, as required by the Mining Regulations. The mine was also safe at that time; for although stoping work had been car-



7. Ideal cross section of the Ophir mine; showing fissure vein to the right, and chimney to the left. The dotted line indicates the base of the bluff.

ried on to some extent in each of the adits, the roof was well supported by pillars and masses of ore. It was pointed out to the superintendent however that as the roof was evidently cut off from the country rock behind it by the fissure vein, so that it hung like a V-shaped body over the worked-out portion of the mine (see fig. 7), it would be necessary to put in ample timber supports before the ore bodies between the several adits were stoped out. In this view the superintendent fully concurred; but his connection with the mine ceased at the end of October. The sanitary condition of the camp is excellent. It could hardly be otherwise without criminal carelessness, located as it is on a slope of gravel drift, and bountifully supplied with pure water from the lake. The surrounding scenery too is picturesque and cheerful.

The Ophir Company was organized under the laws of Illinois, with a capital of \$3,000,000, in 300,000 shares of \$10 each. The stock was eagerly

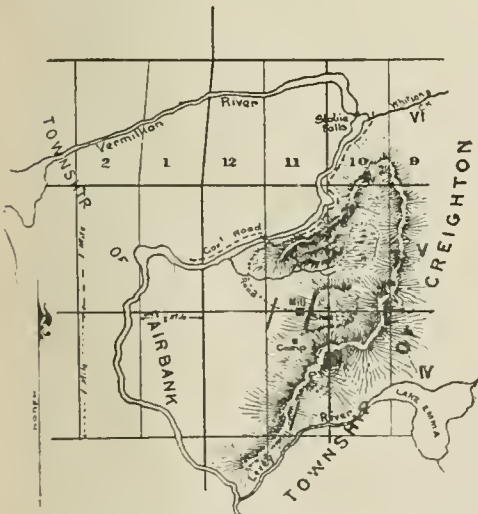
sought after at first, and large blocks were subscribed for by Americans who visited the mine and carried away samples of the ore. Numerous assays of these samples showed it to be very rich; but having been selected for their richness, no prudent dealer in mining stocks would consider that they represented the average ore of the vein. A mill test made at the Houghton School of Mines however was regarded as much more reliable. Three lots treated there, aggregating 5,170 lb. were reported to yield 9.7 ozs of gold and 6.15 oz. of silver. On the strength of this report sales of stock were readily made in the spring of 1893, but the financial panic which swept the United States soon afterwards caused many of the purchases to be cancelled. For this and other reasons of an administrative nature, the Company has been working along under difficulties. The mine was absurdly overstocked, and this is a too common fault in Ontario, as well as elsewhere; yet there does not appear to be any sufficient reason for doubting that it is a good gold property.

How the mine was stocked.

THE CREIGHTON GOLD MINE.

The Creighton gold location occupies portions of 11 in the fourth and fifth concessions of the township of Creighton, in the district of Algoma East. It is reached by a colonization road which is intended to connect Larchwood station on the main line of the Canadian Pacific Railway with Whitefish station on the Sault Ste. Marie branch, through the townships of Balfour, Creighton and Denison, and which is completed to the bridge crossing the Vermilion river on lot 12 of the fifth concession of Creighton. The road in Balfour runs through a section of very good land in the valley of the Vermilion river, but at Whitson creek on the sixth concession of Creighton a range of Huronian schists comes into view which extends easterly and southerly for many miles. From the creek to the bridge over the Vermilion the road skirts the foot of the range of hills across lot 10 in the sixth concession

Location of the mine, and how to reach it.



8. Creighton gold location.

and lot 11 in the fifth, with the river flowing southward close to the right. From a point near the bridge the Creighton Gold Mining Company has opened a road southeastward around the rocky hills to the line between the fourth and fifth concessions and along that line to the mine, two-thirds of the way across lot 11. The hills form a semi-circle towards the north, enclosing a beaver meadow, and they sweep around eastward through lot 10 and south

In a tract of Huronian schists.

Outcroppings
of quartz
veins on the
property.

Exploratory
work.

Sinking a
shaft.

The mill.

towards Lake Emma and the Levy river, throwing out low spurs over the southern portion of 11 in the fourth concession, two or three of which are gray with splashes of quartz. This conspicuous showing of quartz is nearly on a line with the north and south vein on which the Company's shaft has been put down, but the connection has not been traced. On the west side of the location are two outcroppings of quartz which have a northeast and south-west course through low ranges of schist; but although some openings have been made upon them there are no clearly defined walls to denote veins. Here as elsewhere on the lot where outcroppings occur the quartz and the hornblende schist are closely mixed, as if they had undergone partial fusion, presenting a mottled appearance with white as the prevailing color.

The location was prospected four years ago by J. R. Gordon, C.E., and exploration work was undertaken by him two years ago for a syndicate of Ottawa men which afterwards organized as the Creighton Gold Mining Company, with a nominal capital of \$1,000,000. The site selected for sinking a shaft on the north and south vein is where the line between the fourth and fifth concessions crosses. The country rock of black hornblende slate has a north and south course and dips eastward at an angle of about 45°. The vein has the same course and dip, and although much broken at the surface it is shown to be contained within well defined walls below. The shaft has been put down to 160 feet, keeping close to the foot wall, and without change of dip in the whole of that depth. A selvage of soft slate varying from six inches to two feet in thickness lines the foot wall; the hanging wall has not been exposed, but by borings the vein is found to have a width of 17 feet. At 80 feet there is a drift or level of 12 feet, and at 130 feet another of 25 feet. The bottom 30 feet of the shaft is used as a sump to hold water, a large flow having been struck at the first level which demands the constant working of a pump. About 200 tons of ore was on the pile at the date of my visit (October 13-15) and the mine was in a condition for raising about 20 tons per day with one shift of miners. The vein matter is chiefly a bluish colored quartz, with markings of flesh colored felspar, and banded in parts with hornblende schist. There is no appearance of free gold in the ore, but numerous assays have shown yields of \$4 to \$20 per ton; the gold is said to be in very minute particles, calling for extreme care in treatment to save it.

A mill was erected last year close to the shaft. The main part is 24 feet square and 54 feet to the plates, three stories high. An addition of 24 by 30 feet and one story high provides room for a hoisting engine and machinery to treat the ore. On the second floor is an automatic feeder, and on the third a Dodge crusher manufactured by Fraser and Chalmers of Chicago with a capacity to crush 40 tons of ore to the size of nut coal per day. The ore is raised to this story direct from the bottom of the shaft by a friction drum made at the Baldwin Iron Works, Ottawa. Water to supply the mill is also raised to a tank in the third story by a pulsometer pump. The engine house is attached to the mill, and contains a boiler of 100 h.p. capacity to work the engine, drill and machinery for crushing and milling the ore.

The mill selected to treat the ore of the Creighton mine is one known as the Crawford Improved Gold Extractor. Many merits are claimed for it by

he inventor, and in Colorado it is said to be successful in saving a high percentage of the gold. But the one placed in the Creighton mill for some cause did not realize expectations. It was started on the last day of my visit to the location, under direction of Mr. Strickland of Peterborough, a representative of the inventor; but much difficulty was met with in trying to get it into smooth running order, due it was believed to faultiness in construction. The small quantity of ore treated was very finely milled, but stoppages owing to hot journals were too frequent for economic work. I learned afterwards that the trial was continued for a week without any improvement, when the mill was closed down pending the return to the country of the inventor, Mr. Middleton Crawford. Testing the
Crawford
Improved
mill.

All work on the Creighton mine, including the putting down of the shaft, opening testpits and erecting the mill building, has been done under the superintendency of Mr. Gordon. A substantial boarding house has also been built on the location.

On lot 2 in the fourth concession of Fairbank, on the west side of the Vermilion river and about two miles southwest from the Creighton mine, there is a large exposure of a quartz vein. This was explored in the fall and early winter of 1891 by Mr. Gordon for an Ottawa syndicate, and an opening was made into a hillside to a length of 35 feet upon the vein. The property is known as the Gordon Lake gold mine. The formation and the quartz outcroppings are the same as at the Creighton mine. Gordon Lake
location.

THE BELMONT MINE.

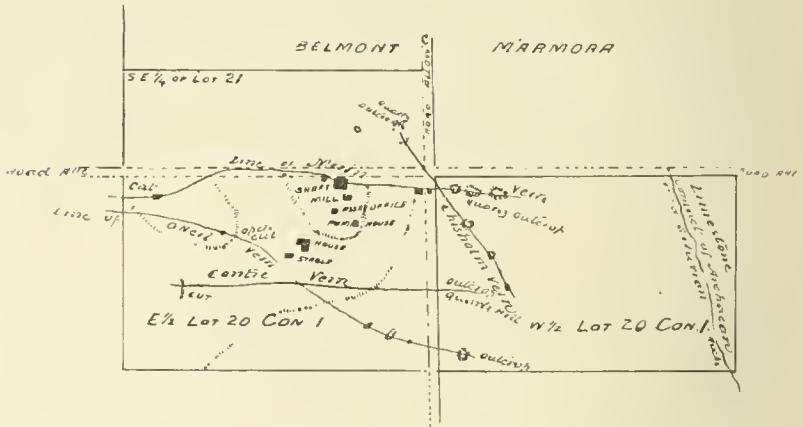
Belmont gold mine is in the township of that name in the county of Peterborough, and consists of the east half of lot 20 in the first concession. It is about ten miles northwest of the village of Marmora by the highway, from which place a railway track has been graded to an iron ore deposit upon an adjoining location owned by T. D. Ledyard of Toronto. An area of calc schist extends northward from the Silurian limestones to within a mile of Belmont mine, where it lies up against a wide band of diorite. The gold-bearing veins are in the diorite, and have been traced near to the line of contact. There are three veins crossing the lot, one close to the road allowance between it and lot 21 on an east and west course, a second parallel with it about the middle of the lot, and a third on a northwest and southeast course diagonally across the lot. The first of these is known as the Main vein, the second as the Centre, and the third as the O'Neill. Another vein, known as the Chisholm, is parallel with the O'Neill, and extends from the southeast quarter of 21 in the first concession of Belmont to the west half of 20 in the first of Marmora. The Main vein for a portion of its length underlies the road allowance between lots 20 and 21 of Belmont, but its course is very nearly due east and west. It is said that a party of the Geological Survey had camped upon it for a fortnight several years ago without suspecting that it possessed any value. The merit of discovery was reserved to H. T. Strickland of Peterborough, who while watering his horse by the roadside in 1890 Location of
the Belmont
mine.

The gold-
bearing veins.

Discovery.

Exploration
work on the
property.

observed the vein, broke off some samples with his hammer, and found that they held free gold. The lot had some time before been located to a settler named Brown, whose widow was then in occupation. In July of the following year Mr. Strickland, with A. W. Carscallen, M.P., and Captain O'Neill visited the lot, took away some samples and had them assayed. The results were so good that terms were made with the occupant, the end of which was that Mrs. Brown took out the Crown patent and transferred all her interests to Mr. Carscallen. Exploration work was commenced upon the Main vein on 7th September, 1891, where a shaft was sunk, and open cuttings were afterwards made on the same vein at the eastern end of the lot, as well as on the O'Neill and Centre veins. At this time the location was held between Messrs. Carscallen, O'Neill, Strickland and Burnham, each having a fourth interest. Work was continued until 7th October, 1892, by which time 1,000 tons of ore had been raised, and the property was then let to Middleton Crawford for a year, at a rental of \$100 per month and a royalty. Mr. Craw-



9. Belmont gold location.

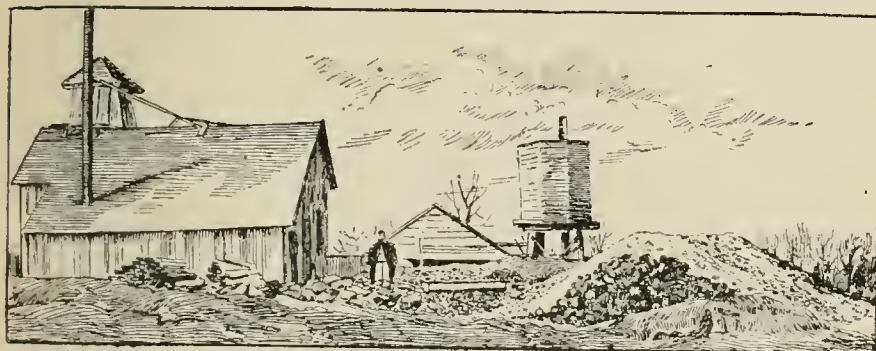
ford brought on one of his own gold mills, and 210 tons which the syndicate had mined was put through as a first test. I was told by Mr. Carscallen that this yielded \$9.53 per ton of free gold; and the concentrates, which were treated at Newark, N. J., yielded an additional \$2.95. The average therefore was \$10.93, and there is reason to believe that all the gold in the ore was not won. Mr. Crawford took out during his term about \$5,000 of gold, and doubtless he would have been allowed to continue operations but for the conviction of the owners of the mine that his mill was letting too much of the gold escape in the tailings.

The shaft on the Main vein was sunk to a depth of 132 feet. The gangue consists of white quartz with iron and copper pyrites. The iron pyrites occurs mostly in fine cubes, and in many places is enclosed with jaspery layers.

Prof. Chapman of Toronto, who made a careful report on the property when the shaft was down to 122 feet, says the Main vein consists of a gangue of white quartz carrying a considerable amount of iron pyrites and a little

Prof. Chap-
man's report
on the loca-
tion.

copper pyrites, and that for some depth from the surface it is decomposed into earthy brown iron oxide mixed with silicious matter and soil. The decomposed or oxidized matter, he states, pans richly throughout the course of the vein. "The width of this vein at the surface is about 3 or 4 feet, or less in places. On descending—as shown by the shaft, the only deep opening yet made in the vein—it widens to 12 and 13 feet; but suddenly, at a considerable depth, it becomes nipped or pinched to less than a foot. The pinch continues for about 20 feet, when the vein again opens, and at the present depth of the shaft, 122 feet, it measures at least 6 feet. Samples taken personally from this depth, and selected so as to present as fair an average as possible, have given me by fire assay \$16 per ton of 2,000 lb. of ore." Prof. Chapman's report was made under date of May 9th, 1893. Referring to the O'Neill vein, he mentions that a trial pit 28 feet deep had been opened near its southeastern extremity. "The vein consists of quartz and disseminated pyrites, and is thus practically identical in character with the Main vein, although apparently of greater width. A fair sample of unoxidized ore taken from this pit gave me by fire assay \$17 gold per ton of 2,000 lb. of ore. From its course or strike this O'Neill vein must cut the Main vein near or just beyond the northwestern edge of the location." Of the Centre vein, he says that a small



10. Shafthouse and mill of Belmont mine.

sample of oxidized earthy matter, mixed more or less with soil, taken from the exposure gave nearly \$5 per ton. "Although satisfactory as showing the actual presence of gold, this assay cannot be taken as an indication of the true yield of the vein, the ground at the spot being entirely unopened." In summing up his estimate of the property, the value of which he affirms that he has not attempted to exaggerate in any way, Prof. Chapman says: "It is undeniable therefore that the quartz veins upon the property, taking one ton with another, carry workable amounts of gold-bearing ore. But the great test after all is the mill test; and the result of the milling operations at the Belmont mine show an average yield of at least \$10 per ton of stuff passed through the mill."

In September of last year another report on this property was made by Messrs. Ricketts and Banks, a well-known firm of mining engineers and metallurgists of New York city, the former of whom is Prof. Ricketts of Columbia

Report of
Ricketts and
Banks of New
York.

College. The report was made to the Moira Gold Mining Company of New York, which had acquired an option on the property. In describing the ore deposits they say : " These consist of a system of quartz veins more or less decomposed near the surface and carrying sulphurets of iron and copper in depth ; traces of galena were also observed. Four distinct veins were noticeable, two with a general east and west trend and a southerly dip, and two with a northwest and southeast trend and a southwest dip. The veins are contained in and interstratified with chloritic schist. The foot wall is schistose and as a rule generally well defined, but the hanging wall is less strongly marked, more or less undulating, harder and gneissoid in character. The sulphurets are scattered through the quartz gangue of the veins with occasional strings and bands near the walls or line of junction of the quartz and interstratified chloritic schist. The chloritic schist is persistent throughout the entire course of these veins, and is plainly observable where crosscuts and openings have been made ; also wherever the quartz outcrops on the surface." In describing the Main vein where the shaft has been sunk upon it they say : " The vein shows distinctly the entire depth of the shaft, a distance of about 132 feet. It has a west-northwest and east-southeast strike, and an almost vertical dip. The width of the vein at the surface is about $3\frac{1}{2}$ feet, but on descending it widens to about 12 feet, pinching again to about $1\frac{1}{2}$ feet. This pinch continues for some distance, say 25 feet, when the vein again widens to about 6 feet at or near the bottom of the shaft. A spur was noticed at a depth of about 50 feet coming in from the north. Near the surface, and in the upper part of the shaft, the ore was found to be more or less oxidized in character, but below this the vein matter is a hard white quartz containing sulphurets in variable quantities, and interstratified with schistose rock. At the time of inspection water was coming into the shaft in quantity from a crevice or split in the vein on the east-northeast side, near the bottom. The foot wall of the vein seemed to be quite regular, but the hanging wall was of a harder character and less well defined." Samples were taken at various points on the location by chipping across the vein exposures, and from the ore piles, and fifteen of these gave an average of \$15.30 per ton. A sample of tailings from the Crawford mill was also tested and gave \$3.51 per ton. This shows a high percentage of loss. But the most reliable result was obtained from a mill test of 12 tons of ore treated in the Crawford Improved mill, the clean-up of which was made at the time of the inspection. This gave a total of \$75.12 gold from the amalgam and \$29.83 from the concentrates, with a loss of \$14.88 in the tailings, or an average content of \$9.98 $\frac{1}{2}$ per ton. " The tailings from this test and from the previous runs made at the mine showed on panning much floured ' quick ' and sulphurets ; also some free gold."

Tests of the
ore by assays
and mill work.

My own visit to the Belmont mine was made on November 18, in the company of Mr. Carscallen ; but the works had then been closed down for some time and the main shaft and nearly all the other openings were filled with water. I have therefore drawn upon the reports of Prof. Chapman and Messrs. Ricketts and Banks, who saw the works in progress, as furnishing a trustworthy account of the veins shown by the workings, as well as the

character and quality of the ores. Both reports concur in the opinion that the veins are true lodes, that the cost of mining and milling the ore should not exceed \$4 per ton, and that an average yield of \$10 per ton should realize a good profit.

In bonding the location to the Moira Gold Mining Company, all members of the old syndicate except Mr. Carscallen parted with their interest in it; but it is not yet certain that the deal will be carried through.

THE LEDYARD MINE.

The Ledyard mine adjoins the Belmont on the south, being upon the east half of lot 19 in the first concession of Belmont. There is an important out-cropping of magnetic iron ore in the northern portion of the lot, which has been leased to a company of New York capitalists. Exploration by borings seems to have satisfied the company that there was a large body of iron ore, of good quality, and a railway track has been graded from the line of the Central Ontario Railway near its junction with the Canadian Pacific to the ore deposit. In exploring the southern portion of his lot Mr. Ledyard discovered a quartz vein which upon examination was found to be auriferous, and some samples were rich in visible gold. The formation is diorite, and two parallel ranges cross the property in a northeast and southwest course for a length of about 300 yards, rising to a height of 25 or 30 feet. These ranges of diorite are cut by two or more veins of quartz having an east and west course, and in the bluff of the eastern range one of the veins outcrops, showing it to lie between selvages of talcose schist and to dip southward at an angle of 45°. About 30 yards west of this bluff a shaft of 8 by 12 feet has been sunk upon the vein to a depth of 45 feet. The vein varies in width from four to six feet, and shows free gold to 25 feet. At the bottom of the shaft it is divided by a horse, so that the walls are 12 feet apart. It is largely composed of a white cellular quartz with iron and copper pyrites in cavities, showing free gold, the decomposition products having leached out largely; but a portion of the quartz is stained with iron, holding iron pyrites decomposed in part into limonite. Some specimens are very pretty and rich. At the southern end of the westerly range, called the Burnt Knoll, there is a large overflow of quartz, and pits sunk upon it indicate the presence of two veins crossing each other below. The Burnt Knoll is 150 yards west of the shaft, and is apparently cut by the same vein. Numerous assays have been made of the ore from this property, nearly all of which show it to be rich; but it is never safe to compute the value of a gold mine from the data of samples. Seven lots of iron pyrites and quartz assayed by Elliot and Chambers of Toronto gave an average of \$326 per ton, and three lots of crystals of pyrites from the Burnt Knoll gave an average of \$90 per ton. One lot from the shaft, "about half a shot bag full of small pieces of ore from all over the ore pile, showing no visible gold," was assayed at the Orford Copper Company's works at Constable Hook, N. J., and gave 4.7 oz. or \$94 per ton. Another lot of 25 lb., mostly from the Burnt Knoll, and described as consisting of "a

The Ledyard location in Belmont.

Magnetic iron ore explored.

Discovery of a gold-bearing vein.

Character and quality of the ore.

Testing the value of the ore.

white, sub-translucent, rust-stained quartz carrying a somewhat large quantity of iron pyrites," was assayed by Dr. Hoffman of the Geological Survey, and shown to contain gold at the rate of 4.608 oz. per ton. A mill test of three tons made by Ricketts and Banks of New York produced \$25.40 per ton, being 92 per cent of the assay value.

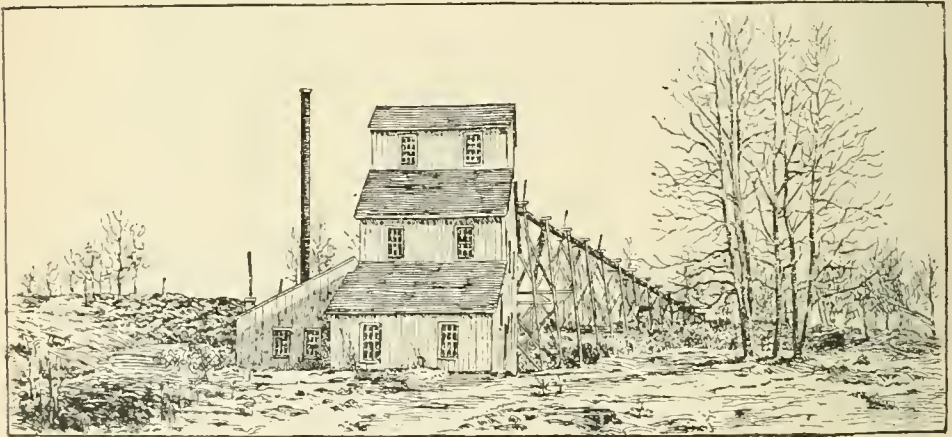
Exploratory work.

Exploratory work on the Ledyard mine was commenced in May of last year under the management of William Nichol, and when I visited it on 18th November nine men were employed. Mr. Ledyard has organized a company to carry on operations, and it is proposed to treat the ore with a Huntington mill.

THE CRESCENT MINE.

Reworking an old property at Malone.

The Crescent gold mine is on lots 16 and 17 in the eleventh concession of Marmora, near the hamlet of Malone. Portions of the property were worked during the period of gold excitement in Hastings over a quarter of a century ago; but though good shows of gold were obtained near the surface, the veins



11. Crescent gold mill, near Malone.

A ten-stamp mill erected.

were not found to be continuous. The Crescent Company was organized in Montreal two or three years ago, and having acquired a right to work one of the old mines at Malone they proceeded to erect a stamp mill and to explore the several outcroppings for gold-bearing ore. The main building of the mill is a substantial frame structure 67 by 26½ feet and three stories high, with an engine room attached of 48½ by 21 feet. A boiler of 90 h.p. supplies the motive power. The mining machinery was furnished by Fraser and Chalmers of Chicago, and consists of a ten-stamp mill with Frue vanners, a Blake crusher, grizzly and self-feeders. The stamps have a drop of 6 to 7 inches, and strike 70 per minute. While in operation at intervals in 1892 and 1893 about 1,200 tons of ore was crushed, yielding 245 oz. of gold, or an average of about \$4 per ton.

There are several veins on the property, having a north and south course and dipping west about 75°. Mispickel occurs in places in the veins, but

they are composed mostly of free-milling quartz. Many pits have been sunk, and there are two shafts, one of which has a depth of 90 feet. In the latter the vein is believed to have pinched out, but the mining work at first was very unskillfully directed and there is no certainty that the ore may not be continuous. It is very doubtful however if it is to be had in paying quantity. The country rock is composed of granite and calc schist, and is very rough and broken.

THE PEARCE MINE.

The Pearce location is composed of 22 acres on lot 8 in the eighth concession of Marmora. The vein has an east and west course through a granitic formation on the east side of the Moira river, and at the surface is only one foot wide. An option upon it was secured by the Hastings Mining and Reduction Company, and early last year work was commenced upon it. This was discontinued in spring owing to high water in the river, and was not resumed until August. In November the shaft of 7 by 9 feet had reached a depth of 90 feet, and at 42 feet a level had been driven eastward 27 feet. At this point the vein widens to 3 feet 8 inches, but at the bottom of the shaft it narrows to 18 inches. At the surface it has a dip of 30° southward, which at 40 feet increases to 46°. Over 300 tons of mispickel ore had been taken out up to the middle of November with a force of seven men, which was treated at the Company's mill in Marmora. The average yield was about \$8 per ton, representing 85 to 90 per cent. of the assay value. It is understood that owing to financial disability the Company was unable to complete its purchase when the option expired at the end of the year, and that the property has reverted to Mr. Pearce.

A mispickel vein in Marmora, worked to supply the new reduction mill.

A PIONEER EXPLORER IN HASTINGS.

One of the earliest explorers for gold in the County of Hastings is Marcus Herbert Powell, clerk of the Division Court at Marmora. Although but little more than fifty years of age, he has the honor of being the discoverer of the Richardson mine in the township of Madoc, which was an exciting event in that region twenty-eight years ago. Mr. Powell retains his interest in prospecting work, and occasionally spends a few days in going over his old hunting ground. Four years ago he discovered gold on lot 24 in the fifth concession of Marmora, which is now known as the Demars mine. It is an arsenical ore, he says, cropping out over a width of 66 feet in a mixed country rock of quartzite and granite. "The ledge has been traced by me for 12 miles from Belmont, through Marmora, and I think it strikes the corner of Tudor." I was unable to see this property, but Mr. Powell shows very fine samples of free gold ore which have been taken from it. Two or three test pits have been sunk, but no actual mining work has yet been attempted.

Marcus Herbert Powell, of Marmora,

discovers the Demars location.

THE RICHARDSON MINE.

The following account of the discovery of the Richardson mine was given me by Mr. Powell, who is an intelligent but unassuming man. It is worthy of being put on record as perhaps the only narrative of the event ever given

His story of the discovery of the Richardson mine, and of

by the discoverer himself for publication. "I began prospecting in Madoc," Mr. Powell said, "in the spring of 1863, and explored Belmont, Elzevir and other townships in search of copper, having for associate a German copper miner named Nicholas Snider. He continued with me for two years and a half, but nothing of value was discovered and we separated. I kept on, taking with me as my new associate one William Berryman. On 15th August, 1866, I discovered gold on the John Richardson lot, the east half of 18 in the fifth concession of Madoc, containing 100 acres. I was following on a seam for copper, and at a depth of 15 feet I struck ore carrying free gold. The seam was six inches wide at the top and was decomposed for six feet; then it was solid rock to 15 feet, where it suddenly opened out into a cave 12 feet long, 6 feet wide and 6 feet high, so that I could stand upright in it. The hanging wall was quartzite and the foot wall granite, while the roof was composed of spar, talc and rocks of various kinds, and the floor of iron, talc, quartzite, black mica and other minerals. The gold was found in all these rocks in the forms of leaves and nuggets, and in the roof it ran through a foot thickness like knife blades. The largest nugget was about the size of a butternut. This was the first discovery of gold in the district. We sold the property to Lombard and Hardin of Chicago for \$36,000. I don't know how much gold was taken out; but I guess the miners got as much as the owners, for I have seen specimens of it all over the country. I remember very well the raid made upon this mine in the summer of 1867, under the leadership of 'Caribou' Cameron. I suppose there were a hundred men with him. The reason of the raid was, that they did not believe there was any gold in the mine. Ropes were thrown over the shaft house to pull it down—Hardin being in charge at the time as superintendent—but before any damage was done 'Caribou' Cameron and another man were allowed to enter the mine and examine it. By this time two or three men of the Mounted Police had come up from Madoc, six miles off, and the raiders quietly dispersed.* Mining was continued until the spring of 1868; but although explora-

the raid
under
'Caribou'
Cameron.

* The following report by Alfred A. Campbell, Inspector for the Madoc Mining Division, made to the Commissioner of Crown Lands under date of May 6, 1867, gives some interesting particulars of the Richardson mine and the attack made upon it, as well as of the general state of gold mining in the district. It will be noticed that he fixes the occurrence of the raid on the Richardson mine more definitely than Mr. Powell, and at an earlier date:

"I have the honor to report for the information of the Honorable the Commissioner of Crown Lands that I have just returned from a tour through the gold region of Madoc; that I find, owing to the very unfavorable state of the weather, it having rained incessantly for the past three weeks, miners have been unable to continue work, the surface water filling up most of the excavations; and in my opinion nothing much can be done for the next three weeks. There have been however about one hundred shafts sunk in Madoc and adjoining townships, and every preparation is being made to continue the work as soon as the weather will permit.

"Prospecting is going on to a large extent, there having been no less than from three to four thousand strangers who have visited Madoc during the last month, a large proportion of whom remain to prospect. Gold has been found to some extent on lot 29 in con. 4 of Madoc, at Downie's Rapids in Hungerford, and also in Tudor, but whether in paying quantities remains to be seen.

"There are at present four four-horse coaches and two covered stages, besides numerous private conveyances, leave Belleville for Madoc daily; also line from Brighton by way of Trenton and Stirling to Madoc. A daily express has also been established. The work of erecting a telegraph [line] is also being rapidly pushed forward.

"At El Dorado, where last fall there was only one solitary log shanty, there have been already erected some eighty buildings, with many more going up; in Madoc some eighteen new buildings are also being erected. Messrs. Gilbert and Turley are importing a steam

tion work has been undertaken at various times since, no gold has been found. There were 19 acres in the location, which I had under lease from Richardson for a consideration of one-half of the mineral won. In dividing the proceeds of the sale to Lombard and Hardin, Richardson got \$21,000 and Barryman \$1,500. I gave my old associate Snider \$3,500, and had \$10,000 left for my own share."

THE MARMORA GOLD MILL.

It is now more than a quarter of a century since gold was discovered in the county of Hastings. For several years mines were worked at various points in the townships of Marmora and Madoc, and a number of mines gave good promise to their owners. Several mills for treating the ores were built, and excitement at times was raised to a fever heat as new discoveries were made. But in almost every case it was found that when a shaft had been sunk to the water-line the ore ceased to be free milling, and no process then known made the economic treatment of it possible. The mispickel, although still rich in gold as shown by assays, was too refractory to yield the precious metal in paying quantities; and notwithstanding that various methods were tried and large sums were wasted on new experiments, conviction slowly settled down on the minds of capitalists, miners and metallurgists alike that there was no money to be made in mining or milling the mispickel ores of Hastings. But the disaster which a short time ago overtook silver mining has led to a re-awakening of interest in gold mining, and once more attention has been directed to the old Hastings field and to improved methods of treating its mispickel ores,—for the genius of the inventor has not been dismayed by the failure of former methods. The most successful of these has been put to the proof of a mill test for the first time in the village of Marmora, and the results it has given are such as to merit a detailed description.

Early gold mining in Hastings.

quartz crushing machine, to be put up either at El Dorado or Bannockburn, which they expect to have in active operation in the course of a fortnight or three weeks.

"I have issued some thirty mining licenses, and as soon as the weather will permit the whole country will be thoroughly explored, when I hope to be able to report more fully and satisfactorily that gold exists in paying quantities in localities other than the Richardson mine. This latter promises to be one of the richest mines as yet discovered in any country. Messrs. Lombard and Hardin commenced operations at the mine on Friday the 26th ultimo, but on Wednesday were served with an order from the Court of Chancery, in consequence of which they have suspended all further work.

"I have also to report an unlawful organized attempt on the part of some one hundred miners and others to effect an entrance into the Richardson mine at present in possession of Messrs. Lombard and Hardin, not for the purpose of plunder but merely to satisfy themselves that gold existed in paying quantities, and that the whole affair was not a humbug. Two of the party were allowed to examine the mine, and were quite satisfied with the result. This sort of organized intimidation is much to be regretted, as it may lead others less scrupulous to follow the same precedence, and may lead to acts of injustice and robbery: happily however in this instance, owing entirely to the good sense of Mr. Hardin, bloodshed has been averted and quiet restored. The police were sent for and they together with myself were promptly on the spot; their services however were not required, as matters had been amicably arranged before their arrival. I have however thought it prudent to station a force at El Dorado. This I think has proved the necessity that exists for the organized police force which has been established for this Division."

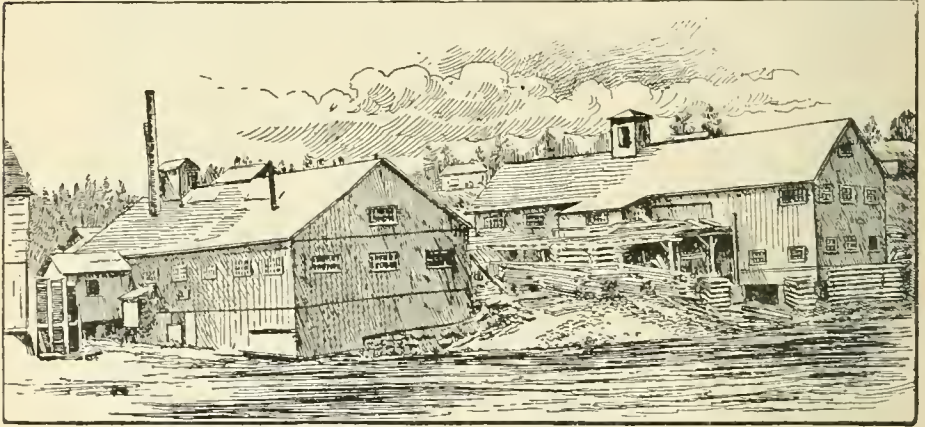
Referring to the police force, the Report of the Commissioner of Crown Lands (Hon. Alexander Campbell, the late Sir Alexander) for 1867 says: "As it was anticipated that a large number of persons would resort to the district for the purpose of prospecting and working for gold, a considerable number of whom would probably be men of violent character and habits, it was deemed necessary for the maintenance of order and the rights of property that a police force should be placed at the disposal of the Gold Mining Inspector, and a troop of twenty-five mounted police was organized under the authority of an Order in Council of the 22nd March, 1867. They were discharged on the 30th September, 1867."

THE WALKER-CARTER PROCESS TESTED.

Testing the Walker-Carter process upon mis-pickel ore.

The original inventor of the Walker-Carter process for treating refractory gold ores is an American named Bancroft, who is said to have spent fifteen years in perfecting it. Patents were taken out in the United States and Canada, the holders of which are Messrs. Walker and Carter of Philadelphia. Through Mr. Arthur Kitson of that city it was made known to Mr. Alexander Keith of Toronto, and by him to Mr. F. B. Allan of the same city. After some negotiations Messrs. Keith, Allan, Kitson and John Scott of Philadelphia acquired the right to use the patent in Canada, and in 1892 the Hastings Mining and Reduction Company was organized to test the utility of the invention on a business scale; as hitherto its success had only been demonstrated in the laboratory. A site and waterpower privilege on Crow river in Marmora were secured from Mr. T. P. Pearce, and a mill was erected on a small granite island in the river, just below the dam. The northern portion of the mill rests on solid rock, while the southern end is supported by cribwork. It is a frame structure of one story, and as first planned was 40 feet by 70; but an addition of 24 feet has been made to the length to provide accommodation

The mill at Marmora.



12. Marmora gold mill to the left; sawmill to the right.

for a subliming furnace to refine arsenic, so that the building is now 40 feet by 94. Work upon it was commenced in November, 1892, and the first run was made in April, 1893, but owing to high water steady work did not begin until June. From that time to the end of the year it ran continuously night and day, saving a few days when it was closed down for additional improvements or slight repairs, or for want of ore supplies.

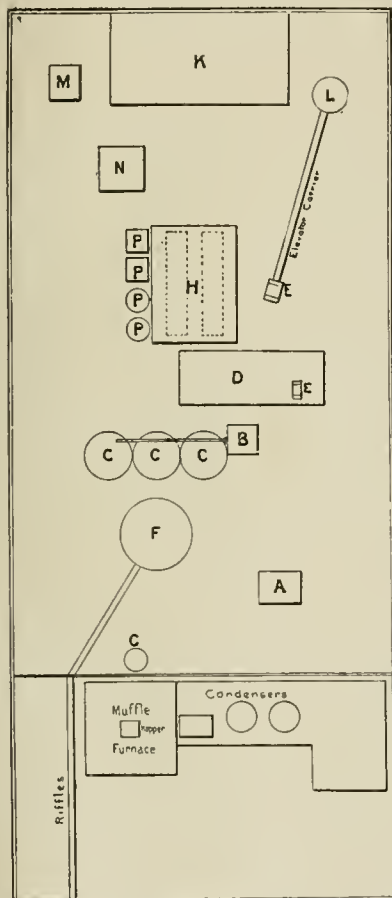
First stage in the process—

Crushing and grinding the ore.

In the process of treating the mispickel ore the first step is to run it through a Blake crusher, in which it is broken to the size of nut coal. As delivered from the crusher it is spread over a drying floor or platform of cast iron plates, resting on brickwork and heated by flues underneath. This floor is $9\frac{3}{4}$ feet by $18\frac{3}{4}$, equal to an area of 183 square feet, and the ore may be spread over it to a depth of six inches. When sufficiently dried, which requires only a few hours, the ore is fed into a Griffin mill and reduced to the fineness of flour (or say a 50-mesh screen) at the rate of 7 to 8 tons per day. Thence it is conveyed through a tube by the action of a screw rake to an elevator and lifted to a hopper of 10 tons capacity under the roof of the mill, 24

feet above the ground floor. From this hopper the ore descends through an automatic feed-valve to a muffle furnace, where it is roasted to drive off the arsenic and sulphur and liberate the gold.

The roasting furnace stands near the centre of the main room of the mill. ^{Second stage in the process—} Its walls are built of brick, upon a stone foundation, and are $8\frac{3}{4}$ feet wide by $12\frac{1}{2}$ long and 12 high, lined inside with firebrick. Its ends are iron plates $6\frac{3}{4}$ feet wide by $9\frac{1}{2}$ high. The fire chamber holds two sets of retorts for roasting the ore, each set composed of four sections with end connections, and built one under another in such a way that the ore at no point in its downward pro-



13. GROUND PLAN OF THE MARMORA MILL.

- A. Mercury retort.
- B. Amalgamator.
- C. Collecting pans.
- D. Cooling floor.
- E. Elevators.
- F. Settling pan.
- G. Clean-up pan.
- H. Roasting furnace.
- K. Drying furnace for ore.
- L. Griffin mill.
- M. Blake Crusher.
- N. Chimney shaft.
- P. Arsenic chambers.

gress through them comes into contact with the flame or smoke. The two ^{Treating the ore in retorts to eliminate arsenic and sulphur.} uppermost sections of the retorts, which receive the charge of ore cold from the hopper, are made of half-inch iron, with internal diameter of 16 inches and length of 9 feet. The others, which are subject to a stronger heat, are built of fireclay, having a shell of three inches thickness. They are ellipse-shaped, with internal diameters of 16 and 21 inches and length of 9 feet. From centre to centre of the sections is vertically $2\frac{1}{2}$ feet and horizontally $2\frac{1}{2}$ feet, thus leaving an intervening space of three to five inches for their full length through which the smoke and heat rise from the fire box to the chim-

ney shaft. Each section of a retort is equipped with a rake, the teeth of which are arranged spirally on a shaft of gas pipe to move the charge of ore from one end to the other in the operation of roasting. The termini of the shaft rest in the end-plates of the furnace, and it is driven by a wheel and its toggle-jointed arm so as to move the rake to and fro within an arc of 120° ,—the same motion being conveyed simultaneously to the rakes in all sections of the retorts. To protect the rakes from the heat of the furnace they have been given four coats of asbestos cement, each coat followed by a wrapping of fine wire to prevent scaling, while by hose connections a continuous flow of cold water is kept up through the shafts. Pine slabs from a neighboring sawmill furnish the fuel of the furnace, and are well adapted for the purpose by the flames and heat they yield.

The operation
of the retorts

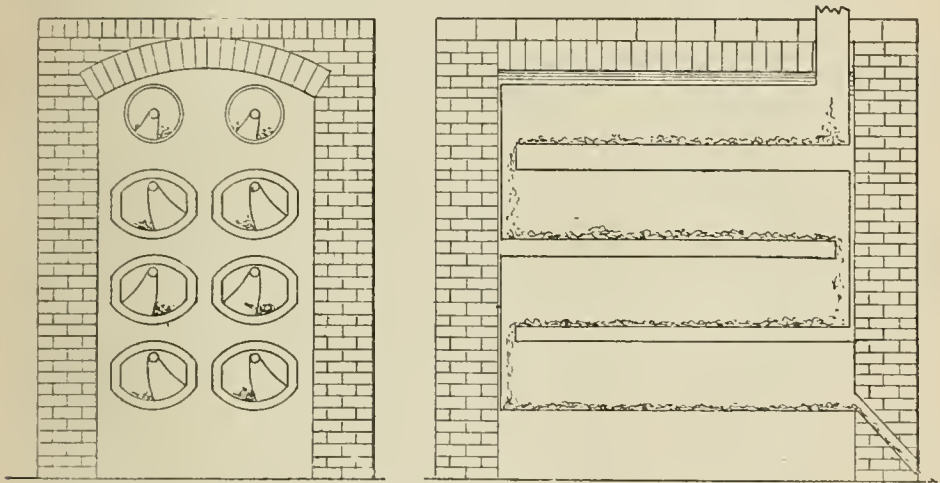
When the plant is in operation the ore is fed in fixed and regular quantities into the uppermost sections of the retorts, at the ends opposite the fire box, and is carried forward by the regular movement of the rakes to fall through slides at the other side into the second pair of sections, and so on into the third and fourth sections, to be finally discharged after traversing a length of 36 feet into a cooling bin on the floor. During its progress the charge continues to be stirred by the action of the rakes, so that every particle is uniformly heated, and as the temperature increases in each successive section the highest roasting capacity of the furnace would appear to be attained. But the thoroughness of the process will depend on conditions. The ore may not be ground to the proper fineness, or the feed-valves may deliver in too large quantities, or the charge may be driven too fast, or the furnace may be maintained at too low a temperature. What is required is the application of enough heat to break up the affinities of the arsenic, sulphur and iron in the whole charge before it reaches the vent, and a knowledge of proper conditions can only be gained by experience. But the Walker-Carter plant has the merit of being readily controlled when what is required is rightly understood, and once it is got into running order the only matter that demands human labor and intelligence is supplying fuel to the furnace; all the rest goes on automatically. The ore is ground to a certain fineness, it is fed into the retorts in definite quantity and makes uniform progress through them, and if an even and sufficient temperature is kept up the oxidizing of the charge will be complete. The iron, gold and earthy material of the ore are deposited in the cooling bin, and the arsenic and sulphur ascend in fumes through the retorts to be held and condensed in outside chambers if provision is made therefor, or otherwise to escape into the air. At the Marimora mill the arsenic only is saved.

Third stage in
the process—

The amalga
tor

In the state in which the ore comes from the furnace the gold may be separated from it by the old and simple operation of panning; but the Walker-Carter process includes an amalgamator of ingenious device which as nearly as possible makes the treatment exactly mechanical and automatic. Simply stated it consists of four parts, viz: (1) Iron hoppers with feed-valves for ore and mercury; (2) Upright iron tube to receive charge; (3) Brick furnace enclosing upright tube; and (4) Water-jacketed horizontal pipe to discharge into collecting vats. The furnace is a brick chamber 3 feet 2 inches square and 9 feet high, with a fire-grate at the base and flues rising to six

inches of the top, which is covered over. Built into this chamber and resting on supports $3\frac{1}{2}$ feet from its base is the upright iron tube, which is $9\frac{1}{2}$ feet high, and 10 inches diameter. A section of 5 feet of it is exposed to the heat of the furnace, and about 4 feet is unenclosed, connecting at the top with a chute from the ore and mercury hoppers. Near the bottom of the upright tube, which is bulb-shaped, is an intercepting pipe in horizontal position which extends outward over the collecting vats. It is about 5 inches diameter, has a length of 12 feet, is water-jacketed two-thirds of its length, and discharges at the outer end by means of a revolving screw rake. The iron hoppers are on a floor over the cooling bin, a small one to hold mercury attached to the side of a much larger one to hold roasted ore. The bottom of the smaller hopper is an axle that in motion revolves at a rate of seven per minute, driven by cogged gearing. A hole of one-quarter inch diameter



14. Transverse and longitudinal sections of the Marmora Mill furnace.

bored in the axle allows a measure of mercury to drop through with each half revolution, to mix with a measure of ore dropped at the same time from the feed-valve of the larger hopper and fall through a short chute into the upright tube.

After the roasted ore has cooled sufficiently in the cooling bin on the ground floor, it is lifted by elevators to a storage hopper of two tons capacity, from which it is delivered as required to the iron hopper below it. Thence it is fed by measured quantities into the upright tube over the furnace, and its work receiving in the passage, as has been explained, the necessary proportion of mercury. No change takes place in the upper portion of the upright tube, but when the section within the furnace is reached the mercury becomes volatilized by heat and permeates the whole body. It cannot ascend in the tube, for the cold ore which is steadily coming down from the ore hopper would at once recondense it; but as it descends and the heat of the furnace increases it is subtilized to a very high degree, and in that state comes into contact with every particle of the mass. The most perfect diffusion is of course in the bulb, where it is nearest the fire. There is no amalgamation up to this point, but everything is ready for it, and as the burthen is conveyed

The alloying of mercury and gold.

out into the cooling water-jacketed section of the discharge pipe in the arms of the revolving rake, we are to conceive a scene of amazing activity. It is not a case of seven women taking hold of one man; the infinitesimal atoms of the vapor of mercury seize upon the nearest dust or grain of free gold in countless numbers, increasing as the temperature falls, and by the time the point of exit is reached there is possibly not an atom of gold in the charge that is not in the embrace of many atoms of mercury. While the panning of roasted ore at the cooling bin will show many colors, samples taken as it discharges into the collecting vats exhibit many globules of amalgam, most of them no larger than pin points, but rarely if ever a color of gold. It does not follow however that all the mercury fed into the amalgamator alloys with gold. That depends upon whether there is much, little or any gold in the ore charge, and how evenly it is distributed through it. The volatilized mercury must recondense as soon as the proper degree of coldness is attained—gold or no gold within reach of its affinity.

Fourth stage
in the pro-
cess—

Collecting the
amalgam.

Three collecting vats (5 feet diameter and 3 feet deep) arranged on a sloping floor under the discharge pipe and a large settling tank (8 feet diameter and 3 feet deep) on a lower level are provided to catch the amalgam. A steady stream of lukewarm water flows from the highest to the lowest, carrying along with it the treated ore mass, worked up into slime by revolving wings in the vats. Silver plates on the wings and copper plates on wall sections of the vats take up the amalgam, and should any particles float over they are saved in the settling pan. This operation is very carefully watched, as it always must be with any system of gold-milling where plates are used. But the loss of quicksilver is very small. At first it was half an ounce for every ton of ore put through the amalgamator, but this rate was reduced as experience was gained. In one run of the mill in which 498½ lb. of quicksilver was used, 496½ lb. was recovered, or an average of 99.6 per cent.

The tailings from the settling tank are carried by a discharge spout over iron riffles a length of 36 feet to the river at the farther end of the mill; but it has not been found that anything of value has been saved on them, except a very small quantity of floured mercury.

Collecting and
refining the
arsenic.

In saving the arsenic the fumes from the retorts are let into a series of dust and cooling chambers where it condenses in the form of gray arsenic, and further treatment is required to refine it. For this purpose a subliming furnace has been erected in the smaller room of the mill. It consists of a muffle furnace and two iron condensers, and the operation produces a white arsenic of fine quality.⁹

Claims made
for the process
as evidenced
by the Mar-
mora mill test.

This mill test of the Walker-Carter process proves, it is claimed, that 90 to 95 per cent. of the gold in mispickel ore is saved, that almost all the mercury used for amalgamation has been recovered, and that the work can be

⁹ As showing the English method of collecting and refining arsenic at one operation, the following extract from an article on Arsenic Mining on the Tamar is quoted from *Industries and Iron* for November 24, 1893:

"The famous mine known as the Devon Great Consols is the principal source of arsenic in England. Early in this century the mountainous spurs flanking the Tamar attracted the attention of mining speculators. We have the authority of the Rev. S. Baring-Gould for the statement that, in spite of large expenditure, no result accrued until in 1844 a fresh attempt on the part of a new company was made with success, as nine feet below the point at which the mine had been abandoned a very rich lode of copper ore, thirty feet wide and one

carried on at a profit with ore yielding \$8 of gold per ton.¹⁰ With arsenic and oxide of iron also saved as by-products, it would appear that the process has solved the problem of treating auriferous mispickel. But the strange part of the matter is, that the owners of mispickel gold mines in the Marmora district do not show any desire to further the enterprise by working their mines and supplying ore to the mill. If not wholly misrepresented, their chief aim and object is to sell their properties for a large sum of money, and leave to some one else the risk and the business of opening and working them.

The Marmora plant is small, because it is experimental; but if it does good work mills may be erected of any desired capacity. It has been run night and day for about six months with five men, three on the day and two on the night shift; and it is but fair to say that for the success attained the credit is largely due to the skill, intelligence and judgment of the president of the company, Mr. F. B. Allan, and its superintendent, Mr. W. H. Wylie.

mile in length, was struck. So successful did the operations prove that at the end of ten months the company divided £70,000. The lode was worked for twenty-eight years, and then gave out, although it would have been abandoned before this had not the waste thrown out as worthless when copper was sought proved rich in arsenic. The Devon Great Consols is now resolved into arsenic works. Copper is still raised, but in a comparatively small amount, and is despatched to South Wales, there to be smelted. As it takes four tons of coal to smelt one ton of copper, it is obviously advisable to carry the ore to the coals and not bring the coals to the ore. Besides copper ore, the mine had yielded vast quantities of mundic or iron pyrites. The arsenical pyrites consists of 25 to 30 per cent. of iron, 12½ to 14 per cent. of arsenic and the rest earthy matter. This goes through several crushing and sorting operations, the latter being carried on by girls from thirteen to sixteen years of age. After washing and jigging—that is, sifting—the arsenical pyrites is conveyed to the first calciner, where it is burnt with low class coal and produces ‘arsenic soot’—that is, arsenic so mixed with smoke-soot from the coal as to be of a gray colour. The arsenic and soot are deposited combined in the chimney, or condenser. This is scraped out and taken to the second calciners to be purified. These calciners consist of revolving iron drums through which a fire of anthracite coal is carried on rotating iron furnaces kept red-hot to which the arsenical soot is fed, the arsenic being sublimed and condensed. The calcining of the arsenic is let out to the workmen. Three men in four weeks will make 100 tons of arsenic; if they make more they receive extra premium; if they burn the arsenic badly, so that it is wasted, they are fined, and the fine has been known to amount to 30s. Some years ago arsenic soot fetched from 2s. 6d. to 15s. a ton; it is now worth from £7 to £7 10s. The chimney in which the arsenic is condensed is a mile long, carried on an incline up the hill, with iron doors in the side. As the hot blast passes up the chimney, it deposits a crust of arsenic crystals on the brick work all round to a depth of from two to three inches, and it deposits minute dust of crystals on the floor. Before the smoke passes into the upright chimney, the height of which is 125 feet, it has to traverse a shower of water, which catches what remains of the arsenic, nothing but sulphurous acid being allowed to escape. The crystals of arsenic are scraped out of the flue or condenser whilst still warm, and are ground in a mill to flour of arsenic, after which it is packed in small barrels containing a little over three cwt. The men who work the arsenic, either raking up the arsenic soot or scraping out the condensers or grinding it in the mill, are obliged to wear mufflers over their mouths and noses to prevent inhalation of the particles. The arsenic workers are obliged to wash themselves thoroughly every day on returning from work, as the arsenic is liable to produce sores if permitted to lodge in wrinkles or folds of the flesh, or about the mouth and nostrils. As a rule it only does this when the worker is careless about his or her personal cleanliness. Otherwise the work is healthy; it prevents all eczema; and the fumes of sulphurous acids, as well as the arsenical dust, are fatal to the germs of disease. Eventually the workmen may come to suffer from chronic arsenical poisoning, indicated by loss of appetite, nausea, frontal headache and anæmia. When this is the case they have to give up the work entirely, but many remain at the works for a great many years without any suffering. The vapor of the burning pyrites contains not only arsenic, but sulphur as well, the iron cinder is cast away, the arsenic is condensed, by the time the upright shaft is reached the vapor is reduced almost entirely to sulphurous acid. The water flowing away from the chimney is like soapy water, so charged is it with sulphur, and the fume blasts the vegetation for some distance round, making Blanch Down an eyesore in the landscape. When the upright shaft has to be entered for any purpose the effect on the eyes is most painful. The men wear linen garments lined with flannel, and the sulphuric acid fumes completely destroy the linen in a few moments, leaving the flannel intact, so that the men go into the shaft in linen and come out clad in wool. Fortunately the necessity for entering the shaft is not of frequent occurrence, or great loss of sight would ensue.”

¹⁰ The percentage of gold lost by the process depends on the roasting. If the arsenic and sulphur are not wholly driven off, the gold contained in them will not be recovered; and small quantities will probably be found in the most carefully roasted ore.

III.

COPPER AT POINT MAMAINSE.

David
Thompson's
description of
Lake Super-
rior.

Extent of the
lake.

"The River St. Lawrence is too well known to need any description from me. I shall confine myself to remarks on the great Lakes, of which it is the drain. Lake Superior may be said to be it's head water; this Lake lies in a deep hollow of the west part of the stoney region, it is every where surrounded by rocky hills, it's northern side rises on an average 850 feet above the Lake, in places much higher, the east side is much the same; almost all of different shades of granitic rock: it's heights are not many miles from the Lake, full of Ponds and Brooks, among moss and Forests of small woods of Pines, Birch and Aspin. The whole is a poor country not fit for cultivation. The south side is still higher, but the heights at many miles from the Lake. The sides of the Lake are mostly of sand or lime stone. The land on the south is much better than on the north side; but not very promising for cultivation. On the north side the Lake receives 30 Rivers from 20 to 100 yards in width, three of which, the St. Louis River at the south west end of the Lake, the Neepego near the middle and the Mishipacoton in the north east corner of the Lake are considerable Streams, and 28 Brooks all of them with many Rapids, Falls and carrying places. On the south side are forty Rivers from 20 yards wide and upwards. Two are 120 yards in width with 41 Brooks, all of them have many Rapids and Falls, but have more water than those on the north side. The evaporation from this great Lake seems confined within it's hills, is condensed before it can ascend above the hills, and returned to the Lake from frequent rains in numerous streams. It is sometimes agitated without any apparent cause. As I was surveying this Lake in 1822, the day was fine and calm (July) about 50 miles from the south west end of the Lake, at noon, the Lake became much agitated, and the waves rolled on the shore as in a breeze of wind; I had to stop for about three hours. On looking at the Lake, about two miles from me, I saw a space of about 300 yards filled with a dark mist which came from the depths below in a rude column of about twenty feet in height, from whence it extended itself horizontally and was lost. As soon as this ceased the waves subsided, and I proceeded on my journey. Lake Superior lies between Latitude 46.27 N. and 48.58 N., and Longitude 84.15 W. and 92.16 W., its greatest length is 386 miles, it's breadth 179 miles; it's circuit is 1617 miles, it's area exclusive of Islands 25,057 miles, it's level above the sea 625 feet. In the north east quarter there is much basalt; Pye Island is wholly of it; close to this Island the Lake has been sounded with 350 fathoms of line, no bottom; on the north side is Thunder Point, of Basalt, it rises perpendicular from the Lake 1120 feet, a great part in appearance is of a fluted form. Here also a line of 350 fathoms

found no bottom ; hence this Point of Basalt must be at least 3225 in height from the bottom. Here then we have a certainty that the bottom of the Lake is at least 1475 feet below the surface of the sea, but it is very probable that parts of the Lake are 600 fathoms in depth, if so, the bottom is 3000 feet below the surface of the Ocean. At the average depth of 200 fathoms, a low average, this Lake contains about 6000 cubic miles of fresh water. In the severest winters, only it's Bays are frozen over, which every gale of wind breaks up, and causes much floating ice. When in 1798 as I was surveying this Lake I went up the Ontonoggan River (by the U. States called the Eagle River) to a mass of native copper, but with my small axe I could not get a piece of it. It lay below a cliff on the lime stone shore of the River, and was much rounded by water. I have lately been informed that it weighs 3000 lbs., and has been taken to Washington at the expense of 5000 dollars. The same year on the survey, about 52 miles northward of the Falls of St. Maries, near Mahmaize, there were five, or six canoes of Indians, who informed me they were then at the old path of their grandfathers, who used to come here for pure copper for heads to their Lances, arrows, axes, knives, and other necessities; by their description the place was about five miles in the interior. I requested to be shown the place, but they said they did not exactly know it, and dreaded the Musquitoes. It appears that in those days, the first settlement of this country, the ornaments of the Churches of Rome came from these two mines, in pieces of pure copper. In the survey of 1822 at the north east end of the great Point, now called Keewenaw, I found a small secure harbor, from which I took specimens of copper ore, which I named Copperas Harbor. This place has since been worked with profit, as has also a considerable tract of country by the people of the United States, who by treaty have about three-fourths of this great Lake by Lord Ashburton's capitulation. On the British side eastward of Thunder Point towards Mishipacoton River, there is an Archipelago of Islands, lying from west to east, of about 100 miles in length, in this direction ; for these two years past (1845-46) they have been closely examined, and the greatest part of this Archipelago of Islands are found to be rich in copper ore, as also parts of the main shore. Companies are now formed to work these extensive copper mines, with what success is yet to be known ; but let us hope that several ships may be loaded with rich copper ore for the ports of England. There are scarcely any hopes this Lake will ever be examined by scientific Men. They have too many hardships to encounter ; they must carry their Provisions with them, live in tents exposed to the Rains and Storms of the Lake, and the worst of all, myriads of Musquitoes. Hopes of profit may cause localities to be explored, but that is all."

Copper on the south and east shores.

A visit to Mamainse in 1798.

Copper on the north shore.

¹ David Thompson's Journals and Surveys in the Crown Lands Department, Appendix pp. 7-10. The extract given above is a literal transcription from the MS. The Journals and Surveys are recorded in thirty-eight books. Thompson's spelling of Mamainse accords very nearly with the modern pronunciation. In Keating's Narrative of an Expedition to the Source of St. Peter's River (1823) it is called Point de Memens, described by him as "a corruption of the Indian word Marmooze, which signifies an assemblage of rocks." Keating further says: "We there met with trap rock in place, but the beach is strewn with water-worn fragments of conglomerates or sandstones." Vol. II, p. 196. Dawson's spelling of the word in 1857 was "Maimanse"; while on the Geological Survey map of 1863, and more recently by Dr. Robert Bell, the word is "Namainse" (Little Sturgeon). Geo. Sur. Report 1876-7, p. 213.

EXPLORATION WORK OF THE MONTREAL MINING CO.

Locations taken up on the Mamainse headland by the Montreal Mining Company.

The existence of copper on the south shore of Lake Superior was known to Jesuit missionaries and others two centuries ago, but Mr. Thompson appears to have been the first white man to learn of native copper being found on the east shore of the lake. Ten or twelve years after the Appendix to his Journals was written the Montreal Mining Company acquired two extensive locations on the Point by purchase from the Crown, and began to explore them for copper and other minerals. The results of operations there are recorded in the twelfth Annual Report of the Directors, under date of 17th February, 1858, for a copy of which I am indebted to their old manager, Mr. E. B. Borron, now of Toronto.² In his report to President Cross of the Company, under date of 31st December, 1857, Mr. Borron gave the following account of the exploratory work carried on at Point Mamainse :

BORRON'S REPORT ON PROSPECTING OPERATIONS.

Sanguine expectations not realized,

"The operations on this Location have not realized the sanguine expectations so generally entertained in reference to it.

The surface show of Native Copper, of Grey and Yellow Ores of Copper, Lead Ore and Silver was such as to warrant a well grounded belief that some of these valuable Metals (but particularly Copper) existed in large quantity somewhere in the vicinity.

In the course of our search many Lodes have been discovered, even on that limited portion of the Location which can alone be said to have been at all explored. The tract in question is situated at the North West corner of the Location, and embraced about one mile in front and a mile and a half in depth, or little more than one-seventh part of the whole.

As we recede from the Lake Shore the ranges of Trap Rock are covered with a considerable depth of soil, which effectually conceals from view all traces of the Lodes which traverse such ranges. There is nothing for it but costeaning or uncovering the rock, by means of trenches at right angles to the supposed general bearing of the Lodes. This was done to a considerable extent last year, and resulted in the discovery of several Lodes.

Two of these, one of which contained Native Copper and the other Yellow Ore, were partially tested by Shafts No. 4 and 5. Three other Lodes which were found by the same means on a Trap range further into the interior than any previously explored, presented a favorable appearance at the surface, but nothing has yet been done to prove them.

and work discontinued.

In the absence of any prospect of *immediate* returns from Mamainse and the probability of a considerable capital being required to develop its resources and constitute it a paying Mine, it was thought advisable in the present state

² Mr. Borron was manager of the Company's mines and works for five years, but resigned his position in 1857. The following reference is made to him in the Director's Report : "From ill health Mr. Borron last autumn announced his determination to resign his office of Manager. He left 1st December last, and has since been unable to proceed further than Sault Ste. Marie. Had it been possible, it was his intention to have met the Stockholders at the present Annual Meeting. The loss of the scientific head of the adventure, and one with whom the Directors worked with so much harmony, and in whom so great confidence was reposed, has occasioned them much concern ; they have however doubted whether the now circumscribed limits of their operations warranted the expense of a Manager of Mr. Borron's attainments, and the staff hitherto employed by the Company."

of the Company's affairs to Lease the Mine should a favorable opportunity of doing so present itself, and in the meantime to recall Capt. Hodge and the party under him at Mamainse. The party returned therefore about the latter end of September.

The following is a brief description of the appearance of the Lodes as shown in the various Shafts at the time of their suspension.

Appearance of
the lodes as
shown by
workings.

No. 1—This Shaft is situated on the Vein where the first Indian Digging was found, and from it the 600 lbs. mass of Native Copper sent below was taken, as well as 800 lbs. more in smaller pieces.

This Vein was from the very first small and insignificant in appearance, and became even more so as the Shaft descended. It carried no regular walls, and presents anything but good indications at the bottom of the Shaft, which is 59 feet 3 inches in depth. Last price for sinking the Shaft, £45 per fathom.

In No. 2 Shaft the Lode looked tolerably well according to Captain Hodge's account at the time it was suspended. The size of the Lode is from $1\frac{1}{2}$ to 2 feet big, carrying a mixture of yellow and grey ore in quartz and calcareous Spar. The depth of this Shaft is 57 feet 6 inches, and price paid per fathom for sinking from £24 to £27 Cy.

No. 3—In this Shaft nothing has been done since February last, when it was abandoned at the depth of 50 feet 5 inches, principally on account of the water, which was heavy. There was no striking improvement or change in the Lode at the bottom of the Shaft. Last price for sinking, £22 per fathom.

No. 4 Shaft was commenced last Summer on a run of yellow Copper Ore on the same Trap Range as that on which Lodes No. 1 and No. 2 are situated, and some distance North of No. 2. I examined it when I was there in the month of July, and was rather pleased with its appearance on the surface. Capt. Hodge subsequently sunk about fourteen feet on it, and informs me that when stopped the Lode was 5 feet in width, with regular walls, and produced stuff well worth dressing, had there been Machinery and Apparatus on the spot suitable for that purpose. Price per fathom for sinking, £25.

No. 5—Shortly before my last visit to Mamainse a Native Copper Vein had been discovered on a range of Trap, some 150 fathoms east of that on which Shafts Nos. 1, 2, 3 and 4 are situated, a strong bed of conglomerate being interposed between the two ranges. On inspecting this Lode, I was favourably impressed with its appearance, and requested Capt. Hodge to put some men to sink on it immediately. Before I left good specimens were taken out within a few feet of the surface, a small box of which I sent down to Montreal on my return. Subsequently however the native copper disappeared from the Lode almost entirely. The lode itself continued about 10 inches wide, and carried to the last very promising spars and mineral soils. This Shaft is 25 ft. 2 in. in depth. The prices paid for sinking, £18 and £20 per fathom.

In concluding my remarks under this head, I have to observe that although the Company have been disappointed in their hopes of speedy returns from this Mine, the operations carried on at Mamainse have tended

Confidence in
the value of
location.

to impress every practical man who has visited the Location with a favourable feeling in reference to the value and prospects of the property in a Mineral point of view, and I am firmly convinced that at no distant period parties will be found willing to embark further capital in the search for richer deposits of Copper than any we have yet been fortunate enough to find. I am equally certain that such richer Lodes exist on the Location.

Everything that was moveable in the way of Stores, Materials and Tools has been brought away, and the houses were left in charge of Charles Rousseau, [Roussain?], who carries on a Fishing business at Mamainse, and contemplates occupying them during the Winter.

The balance at the debit of the Lake Superior Exploration Account is £1009 8s. 5d.¹³

Opinion of the
Directors

In their own Report (p. 5) the Directors say: "The explorations at Mamainse were discontinued in September last—their expense continued to exceed the anticipations of the Directors; and although new indications of a favourable character were discovered, sufficient mineral was not procured to guarantee a return for the expense of working, and the Directors did not think the finances of the Company warranted them in further outlay for experimental purposes. The remarks in Mr. Borron's report in regard to this location are deserving the attention of the Shareholders. The location enjoys a high reputation among explorers and others, and in case of a lease being made of the Bruce Mines the Company might be expected again to turn their attention to this locality. It is possible that enough of its resources have already been developed to induce capitalists to give it consideration."¹⁴ But thirty-five years passed by before capitalists were found with courage to work the Mamainse properties again, and meantime the Montreal Mining Company had met with many reverses of fortune. The following notes of a brief visit to the Point last year will suffice to describe the situation.

NOTES OF A VISIT TO POINT MAMAINSE.

On board the
Telegram.

On the 29th of August I left Sault Ste. Marie by the steamer Telegram on one of her semi-weekly trips to the fishing stations on the east shore of the lake as far north as Otter Head. This boat was formerly in the same business on Lake Erie, collecting catches of fish along the shores of Kent and Essex and around Pelee and the Bass islands for a large curing establishment at Sandusky. She is a staunch craft, as indeed she needs to be with a stiff breeze blowing the whole length of Lake Superior, from west to east, as pretty often happens in the autumn of the year. No other boat is regularly employed on the route, and so whatever freight or passenger business is to be done along the east shore the Telegram gets it.

Among the passengers were two or three men for the lumber woods, and a party of four or five who were going to examine a granite location near

¹³ Report of the Directors of the Montreal Mining Company to the Shareholders at the Annual General Meeting, 17th February, 1858, pp. 12-14.

¹⁴ The cost of mining copper, including the expenses of management, is given by Mr. Borron on the quantity raised, dressed and shipped at Bruce Mines for the year 1857. The total quantity was 467 tons 13 cwt. 2 qr. 3 lb., estimated by analysis to produce 20.28 per cent. of metal: and the average cost on board at the mine was £17 6s. 3d., or say \$69.25. This was equal to \$3.11½ per unit, while the selling price was about \$4 per unit.

Cape Gargantua. One of the owners of the property is Mr. Joseph Cozens A granite location near
 of Sault Ste. Marie. He had shown samples of the stone to Messrs. Cart- Cape Gar-
 wright Bros. of Detroit, who have large stone-cutting works in that city, and gantua.
 Mr. O. E. Cartwright was the leader of the party going up to prospect the
 location. Mr. Cartwright is an amateur astronomer as well as a stone-cutter,
 and claims to have had precedence of Mr. Andrew Elvins of Toronto in the ob-
 servations which led to the discovery of the fifth moon of Jupiter. Like Mr.
 Elvins too he has an opinion on the selfishness of Dr. Barnard of the Lick
 Observatory, who was enabled by the suggestions he had received to locate
 the fifth moon through the great telescope at his command.⁵ Mr. Cartwright
 was greatly pleased with the samples of granite which Mr. Cozens had shown
 him, and informed me that if the stone was to be had in quantity his firm
 was pretty certain to purchase the property. As to working it, that might
 depend on the tariff. "If cut-stone was on the free list we would have
 \$25,000 of machinery there before snow flies." I have learned from Mr.
 Cartwright since that he was well satisfied with the location, and his firm
 had made prompt arrangements to buy it, but another party interested in the
 property with Mr. Cozens demanded a price so far above its value that the
 negotiations were abruptly ended. Mr. Cartwright does not regret his for-
 tune however, as he has learned enough of the region to satisfy himself that
 locations of equal if not greater value are to be had on the public domain.
 He has obtained very fine samples of granite in colors of gray, red and white.

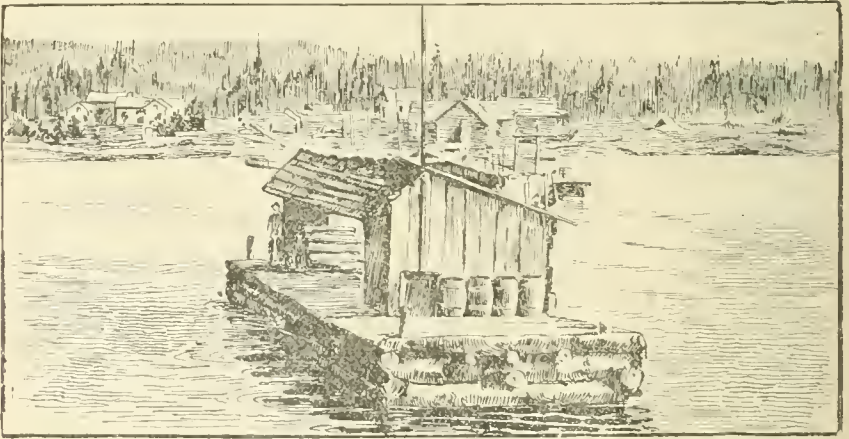
Going up Whitefish bay we met a heavy sea, the wind blowing strong
 from the northwest, and the Telegram pitched and rolled in a most uncom-
 fortable way for landsmen. But she kept steadily on, taking a northerly
 course around Gros Cap, and getting in the lee of Isle Parisienne, and again
 of the Sand islands beyond it. Goulais bay lies to the eastward beyond Gros
 Cap, and beyond a second headland is Batchawana bay, which extends Northward to
 inland about twelve miles. A low island of the same name occupies a large Batchawana
 area on this bay, while lying to the west is a gravelly headland which serves bay.
 to shelter the bay from the prevailing west winds, the southern extremity of
 which is known as Point Corbeau. We reached the landing at "Caribou" Cam-

⁵ In justice however to Mr. Elvins it is only proper that his title to rank as a discoverer should be stated, although it is not a matter strictly pertinent to this Report. Mr. Elvins bases his claim to priority upon the following documentary evidence: 1. A series of letters on the Origin of the Solar System printed during 1872-3 in the Toronto Leader, and articles in various English publications, in which he enunciated the view that Jupiter and other planets have been and are throwing off matter which has, or will become, satellites,—a view long held by him, and revived by the interest being taken in the great Red Spot on Jupiter, then a very prominent feature on that planet. 2. A special paper on the subject read on the 10th of March, 1891, before the Astronomical and Physical Society of Toronto and published in its Transactions for that year. 3. A letter written in December, 1891, by Mr. Elvins to Dr. Barnard, to whom was also sent a little later a copy of the Transactions. This letter was due to some lantern-slides made from drawings of Jupiter by Dr. Barnard when he was in Tennessee, and exhibited before the Society by Mrs. Proctor in November. After disclosing his theory Mr. Elvins suggested that during the approaching opposition of the planet careful search be made for new satellites. 4. A letter dated 2nd January, 1892, in which Dr. Barnard acknowledged the receipt of Mr. Elvins' communication and referred both to Jupiter and to the Red Spot. 5. Newspaper paragraphs originating in California to the effect that on the resignation of Dr. Crewe, one of the Lick observers, in the summer of 1892, and after a struggle with the authorities, Dr. Barnard had succeeded in obtaining more frequent use of the great telescope. 6. After the discovery of the fifth satellite in September, Mr. Elvins wrote to Dr. Barnard a letter in which, after alluding to various matters connected with the discovery, he heartily felicitated the discoverer, and expressed the hope that as time passed and still better telescopic facilities became available the Doctor would discover other moons, of the existence of which Mr. Elvins had no doubt,—a cordial and manly letter which to this day has gone unnoticed.

Good land at
the head of
the bay.

From Perry's
Landing to
Sand bay.

eron's old mill site at 8.30 p.m., after a run of six hours from Sault Ste. Marie, and tied up for the night. Next morning at 5.30 we steamed up to the head of the bay, past the Batchawana and Harmony rivers, and unloaded a cargo of supplies for Perry's lumber camp. The bay is surrounded by high ranges of hills, which in places recede a mile or more from the shore and in places overhang the water's edge, but everywhere they are thickly covered with small timber. While the boat was unloading I walked with Mr. Cozens some distance out on the lumberman's road, and noticed that the soil was a rich black mould on which the grass grew luxuriantly. The timber is small, being apparently a second growth, but it is very dense. The pine forest is some distance back from the shore. The waters of Batchawana bay north of the island are shallow, and there is great risk of running on shoals. We left Perry's Landing at 9 o'clock and reached Sand bay at noon, a distance of 37 miles. The round headland west of Batchawana bay is composed of gravelly drift, but beyond it is what appears from the steamer to be an outcropping of sandstone, with a beach of yellowish sand extending northwestward several miles into Pancake bay (Anse aux Crepes) —the southern boundary of the Pancake mining location. Several high ranges of hills run parallel with the shore, covered to their summits with



15. Roussainville, on the Mamainse headland.

timber. At the highest point, about 1,300 feet above the lake, surveyors in the employ of the United States Government have planted a station for triangulation work. We took on board the officer in charge of this party near the Sand islands on the return trip.

Pancake Point, on the west side of Pancake bay, is the most southerly part of the Mamainse headland, the shore line of which runs northwestward and northward by Whiskey Point to Point Mamainse, above Sand bay. One mile north of Whiskey Point is Roussainville, a fishing station, which is headquarters for Captain John Roussain, who holds a license to fish from the Point to the northern boundary of Sand bay location.

Sand bay is a beautiful half-circle sheet of water on the south side of the mining location of that name, half a mile wide from Copper Point on the

Roussain-
ville.

Sand bay.

south to Mineral Point on the north, having a shore of yellow sand, and densely timbered on the east and south. Its waters are shallow, and boats of the capacity of the Telegram cannot get nearer the shore than 400 yards. On the north side, near a wide sand beach, are the office and warehouse, a large boarding house and the mining manager's residence, all built of squared timber, behind which rise a succession of nearly parallel ranges of rocky hills.

The Pancake and Sand Bay locations have a shore line of nine miles—the former with five and a half miles and an area of 4,800 acres, and the latter with three and a half miles and an area of 6,100 acres. They were acquired from the Crown by the Montreal Mining Company in 1856, at forty cents per acre. On the 13th November, 1871, the Montreal Company sold these and sixteen other locations for \$225,000 to the Ontario Mineral Lands Company, afterwards merged into the Silver Islet Consolidated Mining and Lands company. This company in the course of time became disabled by lack of means, and its property was taken over by the bondholders, who in their turn, in April, 1890, sold it to a syndicate known as the Canada Lands Purchase, the manager of which is Mr. Sibley of Detroit.

Proprietorship of Pancake and Sand Bay mining locations.

THE MAMAINSE HEADLAND.

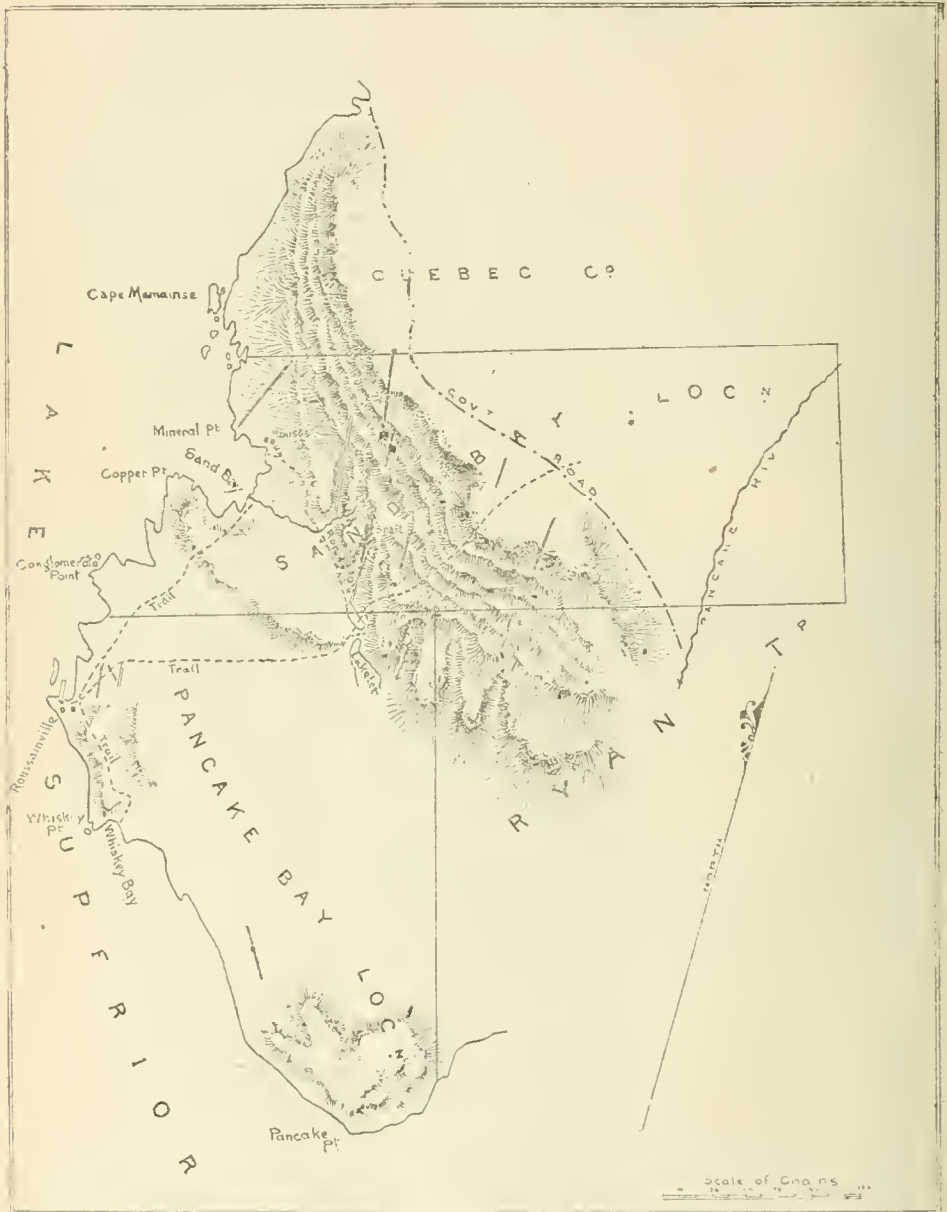
The Mamainse peninsula or headland lies between Sand bay and Pancake bay. The Canadian geologists have distinguished the rocks composing it as the Upper Copper-bearing series, while the later American geologists have adopted the term Keweenaw series, from their conspicuous occurrence on Keweenaw Point on the south shore of Lake Superior—the locality of the famous Michigan copper mines. The American geologists also divide the series into Upper and Lower divisions, copper ore being confined almost wholly to the latter. The Keweenaw peninsula, as well as Michipicoten island and the Mamainse headland, are in the lower division. Indeed the only important difference between the north and south shores at these points is, that while the beds on the Ontario side dip towards the south and southwest, those on the Michigan side dip towards the north and northeast, forming as they do the ends of a great synclinal trough in which lie the waters of Lake Superior. Captain Tretheway has found the eastern end on Mamainse to rest on the Huronian schists, whose outcropping is four and a half miles east from the camp on Sand bay. On the Pancake location there is an outcropping of sandstone along the eastern side, but it is uncertain whether it belongs to the Keweenawan series or to the overlying Potsdam which extends northward from Sault Ste. Marie and Whitfish Point. From Roussainville to Copper Point on Sand bay, along the lake shore, the successive beds of trap and conglomerate are clearly exposed, lying in a course of northwest and southeast and dipping towards the southwest at an angle of about 30°. No change of level takes place in the first mile from Roussainville, but 300 yards back of the camp at Sand bay a bald bluff of trap extends across the location from northwest to southeast. It rises gradually towards the east, where it is overlaid by a bed of what appears to be altered sandstone, but in reality is a felsite or quartz porphyry, reaching at its high-

Keweenaw or Copper-bearing rocks constitute the headland.

Exposed sections of eruptive and sedimentary rocks composing the series.

Traps, conglomerates, felsites, etc.

est point 250 feet above the waters of the bay. Here it is of a light red or brick color, hard, fine-grained and marked with what appear to be lines of lamination, twisted and curved into a variety of beautiful forms under



16. Map of Manitowish headland. The parallel lines show location of mineral veins.

pressure, but which more probably is due to flowage in a molten state.⁶ Dr. Coleman has furnished me with the following description of it :

⁶ In the Geology of Canada (p. 81) Logan describes similar beds which he found on narrow islands on the south side of Michipicoten. The beds are sixty to seventy feet thick and dip southward at an angle of 20°. "They are of a general red color, spotted and

"Macroscopically this rock appears to be made up of a series of thin layers of brick-red and yellowish material thrown into gnarled and corrugated forms. The rock as a whole has felspar hardness, though the yellowish layers are somewhat softer than the rest. Under the microscope quartz is distinctly present, sometimes as minute grains, at other times as porphyritic blebs or crystals. A few greenish portions of chlorite occur also; but the mass of the rock consists apparently of a mixture of quartz and kaolinized felspar, greatly charged with particles of iron oxide. The yellowish layers consist almost wholly of the decomposing felspar. The rock, which has a superficial resemblance to some jaspers, is apparently a felsite or quartz porphyry which has been crushed and rolled out, or a very siliceous volcanic sediment. It corresponds fairly well with the rock described by German and Scandinavian writers as *hallelinta*."⁷

The trap at the line of contact with the felsite rises in a bluff about twenty five feet above it, and thence slopes gradually upward to a height of not less than seventy-five feet. The felsite is apparently very susceptible to the influences of the weather, for where exposed it lies on the face of the acclivity like a mass of shingle. It is overlaid as well as underlaid with trap, and farther down the slope is a bed of somewhat similar rock of colors varying from purple to yellowish white, but essentially different. Dr. Coleman describes it as "a compact, wavyly stratified greenish rock, soft enough to be easily scratched with a knife. Under the microscope a few small particles of quartz show themselves, but the rock is seen to consist chiefly of turbid grains, apparently of dolomite, and tiny scales of talc. It is evidently greatly weathered, and may represent a metamorphosed basic

patched with yellowish white, and wherever a crack exists the rock is blanched to a small distance on each side of it. The surfaces are uneven, and peculiarly marked with festooned and finely wrinkled forms, composed of very thin close-fitting laminae, with a ligneous aspect, having a thickness sometimes exceeding one or two inches. The rock scarcely resembles a trap, nor does it bear the character of indurated shale; but it may perhaps be an indurated mixture of volcanic mud and ashes, in which the wrinkles result from a partial flow." Mr. Macfarlane examined the same beds in 1855, and describes the rock as trachytic phonolite (Report of 1855-9, p. 142); while Irving in his monograph on the Copper-bearing Rocks of Lake Superior (p. 343) found it to be "a highly siliceous felsite, closely resembling and plainly belonging with the red rock of which Mount Houghton on Keweenaw Point is formed, which makes up much of the central mass of the Porcupine Mountains, and which forms so many of the red cliffs of the Minnesota coast of Lake Superior. The resemblance is both macroscopic and microscopic; while the peculiar 'festooned and wrinkled' markings, 'composed of very thin, close fitting laminae with a ligneous aspect, noticed by Logan, are precisely what I have repeatedly described in the foregoing pages as characterizing similar rocks in so many places in the western half of the Lake Superior basin. These markings are doubtless due to a viscous flow, and are much the same as are found to characterize the modern rhyolites." For further description of the lithological character of rocks of the Keweenaw series Van Hise deserves to be quoted. "The felsites, quartz porphyries and other acid rocks—in the earlier reports frequently called jaspers—and amygdaloids were by many of the earlier authors supposed to be metamorphosed sandstones. This position is, I believe, for the acid rocks, held by no writer at the present time, with perhaps one exception, and for the amygdaloids by none. The work of Wadsworth, Pumpelly and Irving has demonstrated beyond all doubt that these rocks are original eruptives. The Keweenaw is now generally recognized as a series many thousands of feet thick, consisting of interbedded lava flows and water deposited detrital material, derived chiefly from the contemporaneous igneous rocks. The volcanics are predominant in the lower part of the series, the interstratifications of the two are most frequent in the middle portion, and the upper part of the series is free from volcanics." Bulletin No. 86, U. S. Geological Survey, p. 161.

7 "Felsstone or felsite (aurite and petrosilex of continental geologists), an intimate mixture of felspar and silica, forming a compact rock, chiefly of dull, opaque yellow, gray, red or green colors. It might at times be mistaken for a metamorphic quartzose rock, but is readily distinguished by its easy fusibility, relative hardness, and its weathered, bleached surfaces. Common among the Silurian rocks of Wales and Cumberland; the Pyrenees; the Alps. *Hallelinta* is a flinty, fissile or laminated variety of felsstone." Prestwich's Geology, vol. 1, p. 46.

volcanic ash. It might be called a talcose dolomite or a dolomitic soapstone." This band outcrops for 80 or 100 yards along the road which leads to Copper Creek mine. From the bay to this point is a little more than half a mile. The road continues to rise, crossing alternating beds of conglomerate, amygdaloidal trap and common traps of various colors, until the mine on Copper creek is reached at an elevation of 275 feet above the bay.

A medley of
"caps."

The whole front of the location on the lake side northward of Mineral Point is a mottled trap, in places of a greenish and in others of a dark reddish or purplish color : but at a small lake near the upper boundary line, which is separated from Lake Superior by a wall of rock 25 yards wide, the trap changes to green and is of an amygdaloidal character. A well beaten path leads from this lake direct to the camp on Sand bay, crossing on the way a low ridge of trap of considerable breadth. A point of trap which runs down to the bay to the west of the camp is in its upper portion of black or dark green color and of uniform crystallization, but at a depth of about ten feet the color changes to purple and it is filled with amygdules of calcite. On the eastern side of the bay the trap is of the same character as that on the lake side, both in color and lustrous mottling. The mottled appearance suggests that the rock is a species of conglomerate, there being dark pebble-like bodies of hard substance imbedded in a matrix of green. The latter from its comparative softness wears more readily away, leaving the harder nodules to stand out like small mamillations over the face of the rock.

A DIFFICULT REGION TO EXPLORE.

An arduous
task for the
prospector,

The southern part of the Sand Bay location it is said was burnt over about 37 years ago, when the Montreal Mining Company was prospecting it, but it is now clothed with a very thick growth of spruce and poplar. Farther back it is densely timbered with cedar, spruce, pine, tamarac, black birch and hard maple, so that is with difficulty an explorer can enter it without cutting his way as he goes. The ground too is covered with a tangle of roots, fallen timber and branches, as well as with moss and leaves, and none but the most experienced prospectors can venture to explore it with any hope of success. Captain Trethewey however has found that by conducting operations in the winter, on snowshoes, and carefully noting the notches and depressions in the ranges of hills, he is able to accomplish much more than is possible in summer, when the deciduous trees are covered with foliage. The veins have nearly all a north and south course, crossing the formations, and the country rock along their line having been disturbed and washed down at many points the whereabouts of a vein is often clearly defined. Especially is this the case on the crowns of ranges, the line being so distinct as to suggest its having been cut out by the hand of man. Almost all of the thirteen or fourteen veins discovered by Captain Trethewey, he states, have been indicated to him in this way, and in almost every instance his discoveries have been made in the winter season. In spring or early summer he goes over the ground, sinking pits and cutting trenches to verify the winter exploration, and cutting out paths to make future traverse easy.

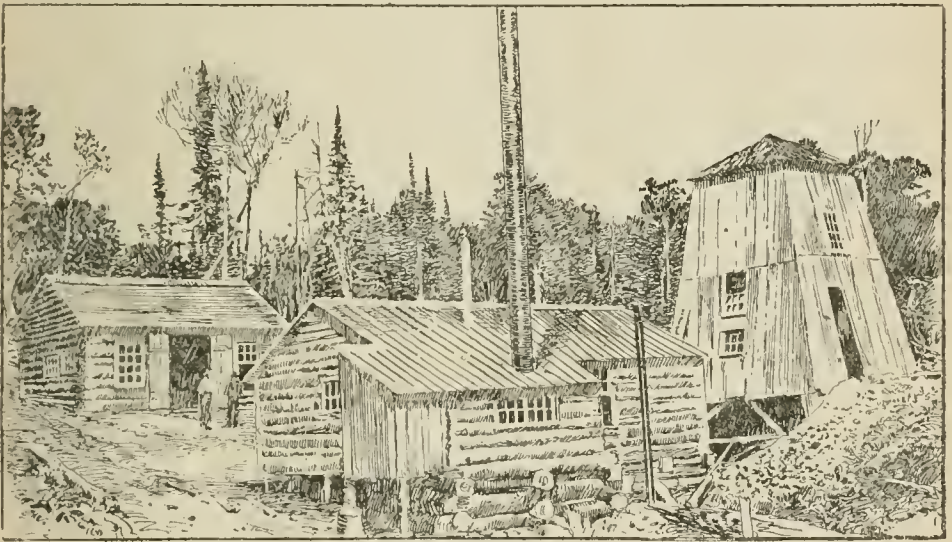
and how he
accomplishes
it.

PROGRESS OF DEVELOPMENT.

The first improvement of the Mamainse locations was undertaken by the Montreal Mining Company, under the direction of Mr. Borron, when five shafts were sunk on different veins on the range a quarter of a mile north-east of the bay. The particulars of this work and the reason for stopping it are given in the extracts from the Company's Report for 1857. The properties were not touched again for a period of seventeen or eighteen years, when a small gang of men was sent down from Silver Islet to explore the Pancake location, but no discovery appears to have been made by them. In the spring of 1882 however the Silver Islet Company entrusted the task of examining the properties to Captain Thomas Henry Trethewey, and with the help of five to ten men he continued exploration work till the spring of 1884. A number of mineral veins were discovered by him, but most of the time was wasted in searching for silver, owing to a small discovery of that metal having been made. Two shafts were sunk on a conglomerate bed at Roussainville to depths of 65 and 87 feet respectively, but the copper ore taken out yielded less than one per cent. An opening upon

Early operations on the properties.

Time wasted in a vain search for silver.



17. Copper Creek Mine, on Sand Bay location.

No. 11 vein on Sand Bay location discovered samples of ore which by analysis yielded many thousands of dollars of silver per ton, yet the aggregate was very small; some samples of copper glance however were found to run 70 per cent. in copper. From this time no further work was attempted until December, 1891, when the new proprietors employed Captain Trethewey to explore Sand Bay location with a diamond drill. Operations were carried on for ten months, during which time borings were made on four veins and five mineral beds ranging in depth from 60 to 365 feet and attaining an aggregate of 3,665 feet.⁸ The beds were amygdaloidal trap and conglomerate, all of which

Enterprise of the new proprietors.

⁸ The average cost of the drilling was \$2 86 per foot, including plant, roads, buildings, expert examination and travelling expenses of Detroit officials: in short, every expense in connection with the work. The diameter of the core is about one inch.

Diamond drill exploration. gave cores yielding more or less copper. The results were so promising that the syndicate decided to undertake development work on a larger and more satisfactory scale.

Sinking a shaft on the Copper Creek vein.

Accordingly an outfit consisting of a 40 h. p. boiler, a 30 h. p. hoisting machine, a four-drill air compressor, car, pumps and a full mining equipment, together with camp supplies for the winter, were purchased and shipped to Sand Bay in November, 1892. The boat delivered its cargo on the 18th of the month, and on the 16th of January the work of sinking a shaft was commenced—an engine house, a shaft house, blacksmith's shop and two boarding houses having been erected in the interval. The site of the shaft is on vein No. 10, or the Copper Creek vein, about a mile and a half from the bay. The vein has a north and south course, cutting across the beds of country rock which have a strike of southeast and northwest. Two small streams join near the shaft house, to run southerly along the vein, upon which a channel several feet deep has been cut. The conglomerate bed forms the hanging wall at the mouth of the shaft, and a cross-cutting eastward shows it to have a thickness of 45 feet, with underlying trap beyond it. The footwall is amygdaloid. Near the junction of the streams the exposure appears to show a thrust or fault in the formations of about 50 feet, but the overlying drift hides the actual position. The vein dips toward the east at an angle of 45°, and is continuous at that angle to the depth (on 31st August) of 295 feet. The width too is equally uniform, being at the surface 6½ feet and at the bottom 6 feet 2 inches. At 80 feet, where a level has been driven southward on the vein 49 feet and northward 20 feet, the vein has passed into the underlying bed of trap, but the walls are well defined on both sides. Here a sump has been sunk in the north level, and a steam pump lifts the water draining into it to the surface. The shaft is dry from the 80 foot level down to 270 feet, but there the water pours in so fast as to make the placing of another pump necessary. The perpendicular depth from the surface at 295 feet, as indicated by an aneroid barometer is 200 feet; by calculation, assuming the accurate dip of the vein to be 45°, it would be 208 feet. The vein matter consists of traps, amygdaloids, conglomerates, quartz and calc spar, holding metallic copper and copper sulphides; but the rich ore occurs only in pockets, and the extent of it is uncertain. This can only be shown when levels are driven in and stoping begins. There is however a good sized pile of rich ore on the surface, and much of the vein matter thrown out on the dump contains ore of greater or less richness.⁹ The shaft is 6 feet by 14 feet, and work had been carried on in it without interruption by day and night shifts from the 16th of January to the time of my visit, or 194 working days. This would give an average progress of a little more than one foot and a half per day, or the raising of 128 cubic feet; but it was somewhat more, as the work done during the period included

⁹ Mr. Sibley informs me that later explorations have demonstrated the fact that the mineral-bearing parts of the veins have an oblique course downward, and nearly parallel to each other. If this is the case it may account for the apparent failure of the lodes in depth, noted in Mr. Borron's report on the explorations of the Montreal Mining Company, as well as for the alternating barren and enriched sections of the vein as shown by the deep Copper Creek shaft.

the level of 49 feet and the sump for collecting water, putting in pumps, etc.¹⁰ The air compressor was worked during the day shift, drilling ten holes an average depth of five feet. The charges were fired at the end of the day's work from an electric battery, when enough rock or vein matter was displaced to keep the night shift employed in hoisting to the surface. All the machinery of the mine was in good running order, and its operations were well controlled for the prevention of accidents,—the best evidence of which is furnished by the fact that no accident had occurred in or about the mine down to the 31st of August; nor has any been reported since.

The Copper Creek or No. 10 vein has been traced north from the shaft house about $1\frac{1}{4}$ mile, and south 1,700 feet by pits and trenches, and at various points it shows fine ores. About three-quarters of a mile north of the shaft another vein has been discovered upon which openings have been made that show good ore for 1,000 feet. Some samples taken from the pits are copper glance yielding as high as 70 per cent., and there are also showings of metallic copper near the surface. The vein runs so close to No. 10 or Copper Creek vein that the two are supposed to unite at a point beyond which the explorations have been made, or possibly they are only parts of the same vein separated by a horse of the country rock.

All fissure veins on the location have a north and south course except No. 4, and two or three have been traced across the boundaries either into Pancake location or into territory not yet taken up in the township of Ryan. No. 4 vein, which comes out on the lake at Mineral Point, runs west of south and east of north, across the stratification. The gangue is trap and conglomerate and is fully 20 feet wide, dipping southeast, and carries native copper and sulphide. A shaft has been sunk upon it to a depth of 40 feet, at a cost of \$8 per foot. At the extremity of the Point, where a section of a vein about 15 inches wide assumes a whitish color, it is said to carry a small percentage of strontium. The bedded veins of course run with the stratification, and as already stated some of them have been shown by the diamond drill to carry copper. On a small island in the lake out from Roussainville, I was told by the captain of the Telegram that he had discovered a lump of native copper in place.

THE LAKE SUPERIOR BASIN.

Concerning the structure of the Lake Superior basin, as well as the order and identification of its rocks, there has been wide division of opinion among geologists. Between Irving and Macfarlane, for instance, there are constant differences as to determination of the copper-bearing rocks; due no doubt to the latter's method of identification by chemical analysis, and the former's by the microscope. The fact is however that the science of petrology has almost been created since the investigation of Lake Superior rocks by Mac-

¹⁰ The shaft has been sunk to a total depth of 308 feet, the average cost of which is reported by Mr. Trothewey to be \$8.50 per foot. The five exploratory shafts put down by the Montreal Company, ranging in depth from 14 to 59 feet and aggregating 206 feet, cost an average of \$17.50 per foot. As cost increases with the depth, the advantage of improved modern methods in mining is obvious.

Irving's final
conclusions.

A synclinal
depression
throughout
the entire
extent of the
Keweenawan
rocks,

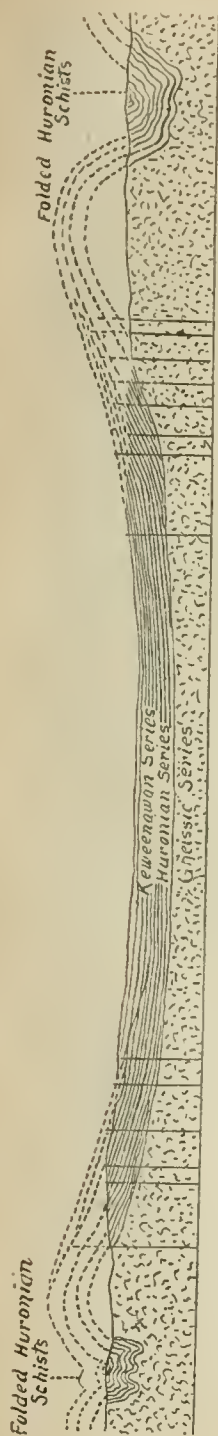
which also
affects the
underlying
Huronian
rocks.

farlane nearly thirty years ago ; certainly very great advance has been made in it with the help of the microscope. In the relation of the Animikie to the Keweenaw or Upper Copper-bearing rocks there have also been wide differences, but they do not need to be touched upon here. The late Mr. Irving of the U. S. Geological Survey was frank enough to confess that his own opinions on the structure of the Lake Superior basin had undergone several changes from the time when his studies of them first began in 1873 down to the completion of his memoir in 1882, and possibly had he lived a few years longer his views might have undergone further modification. His matured opinion, which does not differ much except as regards details from the opinion formed by Logan in 1847, is contained in the following extracts from his monograph on the Copper-bearing Rocks :

"At the beginning of my study for the present memoir, North Wisconsin had been shown to be traversed by a broad synclinal in the Keweenawan rocks, possibly also in the Huronian, which was presumably the continuation of the Isle Royale-Keweenaw Point depression. The exact nature and position of the western termination of the synclinal, the relation to the synclinal of the rocks of the Minnesota coast, and of the Porcupine mountains, and the behavior of the depression to the eastward of Isle Royale, were all points left in doubt, though it appeared exceedingly probable that the entire western half of the Lake Superior basin is a synclinal depression affecting both Huronian and Keweenawan rocks.

Now however I feel able to announce with confidence that the entire lake basin, including not only the western half, but the eastern half as well, is a synclinal depression ; that this depression certainly affects the Keweenawan rocks throughout their entire extent ; that it as certainly affects in very large measure the underlying Huronian rocks, which, while they are greatly folded where extending without the limits of the depression, within its limits form without folds its bottom layers ; that the axis of the depression has, like the lake itself, at first a northwesterly and then a southwesterly direction, with minor bends corresponding to the several bends in the axis of the lake ; that the eastern terminus of the depression is buried beneath the newer formations in the vicinity of the Sault Ste. Marie ; that the western extension passes on to the south shore of Lake Superior with a course curving more and more to the southwest until at the termination in the St. Croix valley, and therefore without the present hydrographic basin of Lake Superior, it becomes nearly due south, the exact termination here again being buried beneath the newer horizontal Cambrian formations ; and that in the region of the Porcupine mountains of Michigan and the Douglas County Copper Range of Wisconsin, there are minor folds superinduced upon the grand synclinal, accompanied in the former case at least by further complications, due to faulting.

The evidence upon which these conclusions are based is to be found in (1) the nearly constant dip inwards of the Keweenawan strata towards the middle of the basin ; (2) in the frequently similar dip of the Huronian ; (3) in the constant order of Upper Keweenawan, Lower Keweenawan, Huronian and



18. Hypothetical section of Lake Superior basin.

gneiss with granite and folded crystalline schists, met with on all sides on going from within the supposed trough outwards; and (4) in the parallelism between the courses of the Keweenawan belts of the north and south shores and of the shore line within these belts.”¹¹

And referring more particularly to the Huronian formation, Irving says:

“The relation of the Huronian to the synclinal is a point of great interest. Beyond question, in the western half of the Lake Superior basin, it bottoms the great trough, for its beds are found dipping inwards on both sides; on the north shore at a low angle, and on the south generally at a high one. It appears highly probable that the eastern part of the trough is similarly bottomed by the Huronian. The Huronian beds are however here found, just without the rim of the synclinal, folded in a complicated manner; for instance, beyond the western end of the trough in Minnesota, in the iron regions of Michigan, on the east shore of Lake Superior, and about the head of Lake Huron. Other folded schists, which possibly belong with the Huronian, occur in Canada north of Lake Superior. The connection of these folded beds with the unfolded is a structural problem still needing investigation.”¹²

To illustrate more clearly his idea of the Lake Superior basin, Mr. Irving presents a generalized hypothetical section of it which may be looked on as taken across from Pigeon River region of the north shore, through Ontonagan, the South Range, and the Menominee region of Michigan and Wisconsin, but not on a straight line, and not drawn to any scale, in which he has attempted to bring out the following points: “(1) The synclinal structure of the lake basin; (2) the partial unconformity of the Keweenawan to the unfolded Huronian; (3) the supposed relations of the folded and unfolded Huronian; (4) the limitation of the Keweenawan outwards by the higher Huronian land; and (5) the origin of the Keweenawan eruptive rocks through fissures arranged around the rim of the trough. If this sketch represents actual conditions, then the downward bowing of the great trough, which subsequently

¹¹ Copper-bearing Rocks of Lake Superior, pp. 412-413.

¹² Ibid p. 417.

was filled with the Keweenaw accumulations, was begun in the Huronian and continued through the Keweenaw. Accompanying this downward bowing was a crumpling of the Huronian to either side of the broader bow—and this crumpling, so far as this sketch is concerned, may have taken place in large measure before the Keweenaw—and an extravasation of molten matter around the rim of the trough.”¹³

SIR WM. DAWSON'S EARLY VIEWS ON MAMAINSE.

Professor (now Sir William) Dawson visited Point Maminse in 1856, and wrote a very interesting paper upon it for the Natural History Society of Montreal. The following extract deals with the geology of the promontory, and the mode in which native copper was deposited in the veins:

Geology of the east shore to the Maminse headland.

“The promontory of Maminse is high and rugged in its interior, and in approaching from the east its outline presents a series of abrupt protuberances. This appearance is caused by the outcropping edges of thick beds of trap and conglomerate, which have, better than the associated tufa and sandstone, resisted the denuding agencies, which in this region appear to have most thoroughly swept all the elevated tracts, scooping out the soft beds and carrying off all the finer materials, as if the forces of breakers and strong currents had been combined in the operation, along with the drifting agency of ice.

At Pancake bay.

In a point at the west side of Anse aux Crepes [Pancake bay], the beds of sandstone and trap are seen in a less disturbed state than in the bay itself. Two very thick beds of amygdaloidal trap are here exposed, and between them are bands of brown ripple-marked sandstone and volcanic tufa. The whole dip west at an angle of 15°. The amygdaloids are evidently superficial lava currents, presenting in some places those pipe-like cavities described by Sir W. E. Logan in his account of this place, and which must have been caused by air bubbles rising through the superficial molten mass. The amygdaloid is much more vesicular above than below, and its cavities and veins are filled with agate, crystalline quartz, calc spar, and flesh colored laumonite.

The shore for some distance follows the strike of these beds, in which the waves, acting on the tufa and mineral veins, have excavated many small caverns and ravines. Some of these excavations are at a little higher level than that of the waters of the lake at present: and they are very instructive in the explanations which they afford of erosions observed even on the summits of the hills.

At Maminse or Sand bay.

Five miles westward of Anse aux Crepes the ledges of the coast are broken across, probably along the line of a transverse fracture of the beds, to form the little bay of Maminse [Sand bay]. On the east side of this bay we find another section of trappean and sedimentary rocks, apparently a little lower in the series than those of Anse aux Crepes. The highest bed of trap is amygdaloidal above, and more compact below, where it rests upon a brown conglomerate with syenitic pebbles, and thin layers of brown sandstone. The

13. Copper-bearing Rocks of Lake Superior, p. 418.

latter consists of grains, often rounded, of quartz, felspar and hard black slate, stained by peroxide of iron, and cemented by carbonate of lime, which also enters into the cement of the conglomerate. The conglomerate rests upon another bed of trap, which in its upper part is largely amygdaloidal, and contains small agates. It also holds syenitic fragments, probably mixed with the scoraceous matter of its surface, at the time when the conglomerate was deposited above, so that, as is often seen in such cases, the upper part of the trap passes into the conglomerate. These rocks present no appearance of igneous alteration subsequent to their deposition, and dip s. 70° w. 35° .

At the head of the bay, and at its western side, the sections show alternations of compact and amygdaloidal trap and hardened volcanic ash, in very regular layers; and holding numerous veins of calc spar, laumonite and quartz, with small quantities of epidote, prehnite, sulphurets and carbonates of copper, native copper, native silver and galena; the mode of occurrence of which will be noticed hereafter. The numerous alternations of thin sheets of trap and tufa that appear in the low ground around this bay indicate a long continued series of submarine volcanic overflows, while the rounded pebbles in the conglomerate point to a rocky Laurentian shore at no great distance. Much remains to be done in this region in separating those igneous beds which have consisted of volcanic ash and scorie from those which are properly trap-pean: but this is rendered very difficult by the consolidation of the fragmentary beds by zeolitic matter, and by the resemblance which hardened volcanic mud and beds of vesicular scorie bear to true overflows of amygdaloidal trap, as well as by the changes induced in true igneous rocks by the percolation of water.

At the head of the bay the ground rises rapidly to a height of 300 feet, in a succession of steep ridges, representing the outcrops of the beds which succeed each other in descending order. The section from the s.w. extremity of the bay inland is as follows, the measurements being taken from a plan prepared by Mr. Coatsworth of the Bruce Mines for the Montreal Mining Company, who are now carrying on works of exploration at this place. The dips are to the westward, the general strike being N. 10° to 20° W., and the angle of dip varying from 25° to 35° . The rocks are, as usual with such materials, very unevenly bedded.

Section of
rocks from
Sand bay
inland.

1. Alternations of trap and tufa, with a bed of conglomerate, which appears to run out a little to the westward of the line of section, in which it does not appear. Large veins of calc spar, quartz and laumonite occur in the trap, and some of them contain small quantities of native copper, native silver and galena. Native copper also occurs in the vesicles of one of the amygdaloids, and one thin bed has its vesicles filled with a steatitic mineral. These rocks occupy a breadth of 500 yards.

2. Argillo-arenaceous beds, in places baked into a compact jaspery rock of a fawn color, with red dendritic stains, in other parts a mottled argillaceous sandstone, similar to that of Anse aux Crepes. Breadth 220 yards.

3. Crystalline and amygdaloidal trap, with a bed of conglomerate. These rocks occupy a breadth of 440 yards, and rise to an elevation of 300

feet. The old Indian workings and the excavations of the present mine are on the summit of this ridge. The lowest rocks of this band are probably tufaceous, and have been excavated into the ravine of a small brook.

4. Very coarse syenitic conglomerate, forming a second ridge. Some masses of stone two feet in diameter were observed in this bed. It occupies a breadth of 160 yards.

The thickness represented by these measurements may be about 2,000 feet; but this by no means includes the whole thickness of similar rocks developed at Maimanse, and which extend both above and below the beds above described. The total thickness seen at Maimanse is estimated by Sir W. E. Logan at 10,000 feet.¹⁴

Occurrences of
copper in
ranges of trap.

The beds included in No. 3 of the above section are those in which the principal indications of copper have been observed. On the summit of the ridge the hard semi-crystalline trap is traversed by a narrow fissure, running nearly with the strike of the beds, or north and south. Its greatest thickness is about six inches, but in some places this has been found to be nearly filled with native copper. One mass weighing 600 pounds has been extracted, and the whole yield of a shaft 27 feet deep and without galleries has been about three tons. The veinstones here are principally calc spar and quartz.

Indian dig-
gings

At a short distance westward of the shaft the vein is divided into two branches. The course of this vein, as well as of most others in these hills, is marked by surface trenches, usually called 'Indian diggings,' though they are evidently erosions similar to those which run along the veins seen on the present beach, and excavated when the surface was undergoing denudation under water. These trenches however afford excellent guides in tracing the veins, and they have served this purpose to the ancient Indian miners, in whose time it is likely that plates of metallic copper, exposed by the removal of less resisting materials, may in places have projected from the bottom of these furrows. The real Indian diggings are shallow holes, sunk at intervals along the courses of the veins, and surrounded by broken pieces of veinstone, along with which are occasionally found stone hammers. These hammers are merely beach pebbles, usually of trap, and having shallow grooves worked around them, to receive withes or thongs used as handles. Most of them are 5 or 6 inches in their longest diameter, but one now in the collection of the Geological Survey, is about a foot in length.

About one hundred yards northward of the shaft just mentioned excavations have been made at the intersection of two veins, one running N. W. and S. E., and the other N. and S. The former is unproductive; but the latter, which is six inches in width, contains small bunches of purple copper, in a veinstone of quartz and calc spar. A few small crystals of copper pyrites have also been observed in it. About 30 yards eastward from the second opening is another vein, running E. 20° N., and wider than either of the others. Its principal mineral contents are green carbonate of copper, with a little

¹⁴ Dr. Robert Bell estimates the thickness at 22,400 feet. Geo. Sur. Report, 1876-7, p. 214.

vitreous copper and copper pyrites. A few minute specks only of native copper have been observed in it. It appears to be very irregular in its width, and at the place where it has been opened the wall on one side consists of amygdaloid, and that on the other of compact trap, probably in consequence of a fault.

It would appear that this ridge is traversed by a multitude of fissures, containing copper and copper ores, and as is generally the case with such veins in trap, very irregular in course and dimensions. Those above described are the most considerable yet discovered. Their value as deposits of copper is not yet determined; but the indications are of sufficient promise to warrant works of exploration. The quality of the veins will no doubt change as they penetrate the underlying tufa and conglomerate, though whether in the direction of greater or less value is uncertain.

MODE OF DEPOSITION OF NATIVE COPPER.

"As the mode of deposition of native copper has been a subject of much controversy, I examined with care, with the aid of Mr. Borron of the Bruce mine, the veins exposed at Maimanse, and shall state the results at which I have arrived for that locality, with the facts on which they are based, without meaning to assert that the mode of occurrence and formation of native copper must in all cases have been of similar character. The veins traversing the trap of Maimanse have been filled with successive deposits of mineral matter on their sides, in the manner of ordinary mineral veins. In the larger veins these are alternate layers of quartz and calc spar, the latter often moulded on the crystalline surfaces of the former, and *vice versa*. In several cases the first deposit of quartz is of an agatiform character, and stained by peroxide of iron, but the greater part both of the quartz and calc spar is crystalline and colorless.

The metal deposited contemporaneously with the gangue of the vein.

The deposition of the native copper has evidently been contemporaneous with or subsequent to that of the quartz and calc spar. The larger masses are imbedded in calc spar, occupying the cavities left in the wider parts of the vein, after its sides had been coated by that mineral. Smaller masses occur in a similar relation to the quartz. In one of the beds of amygdaloid are kernels of copper impressed by crystals of zeolite, which had lined the vesicles previously to the deposition of the metal. In one small vein plates of copper cut across the veinstone of quartz. Such examples indicate deposition of copper after that of the veinstone. In other specimens delicate arborescent crystals of copper penetrate calc spar crystals in such a manner as to give them a general red color, indicating contemporaneous deposition.

"Native silver occurs on the shore in small quantity, in similar dendritic forms, in a vein containing calc spar, zeolites and fragments of trap. The sulphurets of copper occur in precisely the same relations with the native metal. The carbonate is probably a product of oxidation of vitreous copper and native copper near the surface of the rock.

Probably a result of electro-chemical agencies.

The whole of the appearances indicate that the deposition of copper belongs to the period of aqueous infiltration, by which the veins and vesicles were filled after the consolidation of the trap; and the copper, like the calc spar and zeolites, occurs both in true veins and in the cavities of beds of vesicular trap and tufa. Its deposition must therefore be explained, not by igneous causes, but by electro-chemical agencies, decomposing some soluble salt, most probably the sulphate, of copper. Such changes may have been aided by the remaining heat of portions of the volcanic masses, by the presence in them of large quantities of iron in low states of oxidation, and by the further oxidation of that metal evidenced in the red jasper and red laumontite of the veins, and the red conglomerate and sandstone associated with the trap.

One great difficulty in supposing the electro-chemical deposition of copper in these veins is the want of a conducting surface, and one not likely to be acted on by copper salts, for the commencement of the process. Much of the copper however, even when not exposed to atmospheric action, is coated with suboxide of the metal; and I have in several instances observed the crystals of calc spar in these veins varnished with a thin coat of peroxide of iron, or of suboxide of copper, which has been precipitated on their surfaces, and might have formed a better basis for copper deposition than the naked surface of the calc spar. In the delicate dendritic forms the crystallization has evidently commenced from minute points; and this may have been the case also with some of the larger masses, which often have thin plates of fibres connecting them with the wall of the vein. Such connecting threads, if first deposited may have served as conductors.

Such attempts at explanation must however in the meantime be regarded as merely conjectural; and it must be confessed that we can have little accurate conception of the processes that may go on in fissures extending from the bottom of the sea far downward into volcanic masses, and in which a great variety of substances are subjected in different degrees to the combined influences of heat, pressure, and aqueous solution. The main fact in relation to the origin of the metallic copper is that it is a product, not of the fusion of the trap, but of subsequent processes, by which the fissures of that rock were filled by materials regarded as of aqueous origin.¹⁵

IRVING ON COPPER DEPOSITS OF THE KEWEENAW SERIES.

In his memoir on the Copper-bearing Rocks of Lake Superior, published by the United States Geological Survey, the late Roland D. Irving has devoted a very interesting chapter to the occurrence of copper in formations of the Keweenaw series, which will be found invaluable to prospectors and explorers in the search for and development of copper deposits in the Lake Superior region. The information contained in the following extract will be as instructive to Canadians as to Americans:

CLASSES OF WORKABLE DEPOSITS.

"All the workable deposits of copper heretofore discovered in the Lake Superior region fall into one or other of two classes, which we may term belt

¹⁵ From the Canadian Naturalist and Geologist, March, 1857, pp. 3-9.

or bed deposits and transverse vein deposits. The first class includes the cupriferous conglomerates and sandstones, the cupriferous amygdaloids, and most, Bed deposits and transverse vein deposits if not all, of the so called veins carrying much epidote and coinciding with the bearing of the formation; the second class includes those veins which traverse the formation in a direction more or less nearly at right angles to the bedding. No copper has ever been observed in connection with the acid eruptives of the series, nor have any workable deposits been discovered in the massive non-vesicular diabase beds, except as distinctly subordinate to, and directly connected with, the amygdaloid deposits or epidote courses, and always accompanied with an extreme degree of alteration.

The conglomerate and sandstone deposits are simply portions of the Cupriferous conglomerates and sandstones, beds of these rocks, in all respects of the ordinary character, save that they are impregnated with the native copper. Cupriferous deposits of this character are for the most part confined to the thin conglomerate beds which are interstratified with the ordinary diabase flows; but one cupriferous bed of sandstone is known within the upper or purely detrital division of the Keweenaw series, and separated from the nearest trappean flow beneath it by a thickness of many hundred feet of sandstone layers. This is the belt of dark colored sandstone and shale in which occurs the Nonesuch copper bed of the Porcupine mountains. This belt has been traced from Keweenaw Point to Bad river, a distance of about 150 miles; and has been found to contain copper at a number of points in the vicinity of the Porcupine mountains, and again on the Montreal river, the boundary line between Michigan and Wisconsin.

In the cupriferous conglomerates and sandstones the copper occurs in which the copper occurs as a cementing material. as a cementing material, and as a replacer of the constituent grains, being in all cases plainly of secondary origin, and a result of deposition from an aqueous solution. Moreover, the cementing copper itself, *i. e.* that which is to be seen in the thin section between the constituent grains moulding itself sharply around their contours, is often also plainly a replacer of still smaller constituent particles. In the case of the Nonesuch sandstone of the Porcupine Mountain region a large proportion of the particles of cementing copper have within them a core of magnetite. It is indeed not improbable that in all cases the cementing copper is not a deposit in the original interspaces of the fragmental particles, but is always a replacer.

In the thin sections of these cupriferous conglomerates the larger particles of porphyry matrix and fragments of the feldspars are found to be replaced by copper in varying degrees, the metal in the case of the feldspar fragments tending to follow the cleavage directions. In the famous conglomerate of Copper in the Calumet and Hecla mines. the Calumet and Hecla mine in the Portage Lake region the copper has not only saturated the matrix, but has also entered into and more or less completely replaced large sized pebbles and even boulders several inches to a foot or more in diameter. Hundreds of such boulders are picked each day from the heaps of rock before it is taken to the stamps. In these boulders the copper has replaced both the matrix and the porphyritic feldspars, occurring in the latter, when the replacement has not been carried very far, often along

the cleavage lines only. Pumpelly has shown that the deposition of this copper has always followed other great changes in the condition of the porphyry fragments, and notably the replacement of both matrix and feldspars by chlorite and epidote; these minerals having in turn been replaced by the copper. This relation between copper, epidote and chlorite is one which exists also in the altered amygdaloids; and the source of the constituents of these minerals may be found either in the particles of amygdaloid matrix and other basic materials which not unfrequently occur in the conglomerates themselves—in the Nonesuch sandstone forming a predominating quantity—or in the overlying trappean beds, from which they may have descended along with the infiltrating carbonated waters.

SOURCE OF THE COPPER.

The cupriferous amygdaloids.

‘The ordinary cupriferous amygdaloids, such as those which are so largely mined about Portage lake, are, as Pumpelly was the first to show, simply the more or less completely altered and copper-saturated upper vesicular portions of the old lava flows, and are neither independent layers, nor ‘veins’ parallel with the formation. The copper has been introduced into these amygdaloids during one of the later stages of a long chain of replacements, whose history has already been briefly outlined, as worked out by Pumpelly on a previous page. Several paragraphs of his descriptions may appropriately be quoted again in the present connection.

‘Considerable portions of the bed have lost every semblance of an amygdaloid, and consist now of chlorite, epidote, calcite and quartz, more or less intimately associated or forming larger masses of the most indefinite shapes, and merging into each other. Sometimes portions of partially altered prehnite occur. In places, considerable masses of rich brown and green fresh prehnite filled with copper occur; but as a rule this mineral has given way to its products.

‘To this process the copper-bearing beds of Portage lake—wrongly called lodes—owe their origin. Considerable portions of these beds are but partially altered amygdaloids, containing amygdules of prehnite, chlorite, calcite, or quartz, with more or less copper; other portions are in the condition described above.

‘In the still amygdaloidal portions the copper was deposited in the cavities and in cleavage planes of some minerals, and replaced calcite amygdules, etc. But in the confused and highly altered parts of the bed it crystallized free where it had a chance; more generally it replaced other minerals on a considerable scale. It formed in calcite bodies those irregular, solid, branching forms that are locally known as horn-copper, often many hundred pounds in weight; in the epidote, quartz and prehnite bodies it occurs as thread and flake-like impregnations; in the foliaceous lenticular chloritic bodies it forms flakes between the cleavage planes and oblique joints, or in places—and this is more particularly true of the fissure veins which we are not now considering—it replaces the chloritic, selvage-like substance till it forms literally pseudomorphs, sometimes several hundred tons in weight.’

The copper in these deposits is not restricted to that portion of the bed which was originally vesicular, but runs from it downward irregularly into the originally compact portions, following always a great alteration of the rock. The copper however tends always to be very irregular in distribution, and even in the longest worked and most reliable amygdaloids has frequently

and the irregular distribution of copper in them.

to be searched for through many feet of barren rock. In this search the diamond drill is now extensively used, the miners being guided in its use by the occurrence of seams of calcite and epidote, and other alteration forms, which when followed up with the drill are often found to lead to pockets containing much copper.

In one class of amygdaloids, those of the ashbed type,—which I agree with Wadsworth in regarding as merely very highly scoriaceous and open lava flows, into whose interstices the intermingled detrital material has subsequently been washed—the distribution of the copper is sometimes more uniform than in the ordinary cupriferous amygdaloids, so that the whole of the bed may be broken down and taken to the stamps, as is done for instance at the Atlantic mine.

The copper deposits of the Ontonagon region have not had the study given to them that has of late years been devoted to those of the Keweenaw Point and Portage lake districts; so that it is not possible to be quite so positive in our statements in regard to them. The copper of this region never occurs in transverse fissures, but either lies in irregular accumulations—often solid masses many tons in weight—associated with much epidote and calcite, distributed along the course of diabase beds, or else occurs with more persistent and vein-like aggregations of epidote and calcite. The latter coincide always with the bearing of the formation, and commonly also with its dip, but in some cases, as for instance in the once famous Minnesota mine, dip at a higher angle than that of the formation, which they consequently slowly traverse in depth. According to Foster and Whitney deposits like that of the Minnesota mine show another indication of a vein-like character in the shape of slickensided and generally sharply defined walls. The ‘vein’ at the National mine is also peculiar in lying at the base of one of the great lava flows, and immediately above a conglomerate bed, while coinciding with them in both bearing and dip.

It is evident, even with our present knowledge of the deposits of the Ontonagon district, that their history has been essentially the same as that of the Portage lake deposits. In the case of that copper which occurs irregularly distributed, along with epidote and calcite, throughout certain of the trappean beds, the process of replacement has gone on irregularly because of some irregularity of texture in the original rock. Deposits like that of the Minnesota mine may have resulted from the deflection of the altering waters along the course of a pre-existing but not open fissure; the ‘vein’ being in this case, as before, a replacement at least in large measure of original rock substance.

The transverse veins have been mined for copper on Keweenaw Point only, where they are found varying in width from mere seams to 10 and even 20 and 30 feet. For the most part however they do not exceed one to three feet in width, the expanded portions being met with where they traverse the amygdaloidal or otherwise open textured portions of the flows. The same veins which in the amygdaloid and looser textured diabases are expanded and often rich in copper, will when in the more compact and massive beds, such as the well-known greenstone, contract to mere seams without metallic contents; and

the same is in large measure true of their intersections with the sandstone belts. The veins lie always very nearly at right angles to the trend of the beds which they traverse, standing always very nearly the perpendicular. Quartz, calcite and prehnite make up the common veinstone, but they are mingled with more or less of the wall rock of the vein, which frequently predominates greatly over any true veinstone. The veins are in fact for the most part not sharply defined from the surrounding rock, but consist in each case of a network of smaller seams traversing the shattered wall rock. Veins composed almost wholly of calcite are not unknown, but they are never productive of copper. The copper in these veins occurs both in smaller fragments and minute particles intimately mixed with veinstone, and again in masses many tons in weight. The larger masses frequently are found to contain within them portions of the wall rock.

pinch out in
the greenstone
belt.

Nearly all of the productive mines based on these transverse veins are working directly beneath the greenstone, the layer which is described in a previous chapter as constituting so prominent a feature in the geology or topography of Keweenaw Point. This position of the mines is one not due to the non-occurrence of copper elsewhere on the course of these veins, but results from the fact that further south they become buried beneath a heavy coating of drift, while to the northward they pinch out and become barren in the broad greenstone belt.

Phenomena of
the transverse
veins.

These veins, on account of their transverse position to the bedding of the formation, of their often slickensided walls, and from their carrying often a true veinstone, have commonly been regarded as 'true fissures.' That they are on the lines of pre-existing fissures or transverse cracks in the formation there can, I think, be no doubt; but they are not true fissure veins in the sense that the veinstone and metallic matter occupy, along with wall-rock fragments, original fissure space. I see in them simply the results of a rock alteration entirely analogous to that which has brought about the deposition of copper and its associated veinstone minerals within the cupriferous amygdaloids. They are alteration zones which traverse, instead of following the bedding, simply because the drainage of the altering waters has been given this direction by the pre-existing fissures. All of the phenomena of these veins coincide completely with this view; the common occurrence of wall rock within the vein, or rather the embracing of the wall rock masses by the vein; the replacement of wall rock by copper masses; the occurrence of wall rock within these masses; the expansion of the veins and their greater richness where traversing the more readily alterable amygdaloids and looser textured diabases; their contraction and barrenness within the compact and less readily changeable greenstone; and the coincidence of the paragenesis of the vein minerals with that of the cupriferous amygdaloids, are all facts better explicable on this view than on any other.

No striking
differences in
origin of the
several classes
of veins.

Thus the differences in origin of the several classes of copper deposits—conglomerate beds, cupriferous amygdaloids, epidote veins parallel to the bedding and 'fissure' veins transverse to it—which at first sight seem to be great, on closer inspection for the most part disappear. They are all the result of the percolation of carbonated waters, which in the lines of fissure,

the open textured amygdaloids, and the nearly equally open conglomerates, found the least resistance to their passage, and at the same time the greatest susceptibility to their altering power. This susceptibility depended partly upon the very openness of these different rocks, but also, in the case of the amygdaloids, in the presence of a large proportion of glass basis, the most readily alterable substance among rock constituents.

CAUSE OF PRECIPITATION OF THE COPPER.

"The source and the cause of the arrest of the copper which was carried in with the altering waters are other and more different questions. Its home has commonly been regarded as being within the mass of the trappean flows themselves, with which it is supposed to come to the surface. Another view is that it was originally deposited in a sulphuretted form along with the detrital members of the series from which it was subsequently leached, partly in the shape of a sulphate, but principally as a carbonate and silicate. The latter is the view which Pumpelly has elaborated¹⁷; to whom also is due the credit of having advanced the only satisfactory view as to the cause of arrest of the copper in the places where it is now found. He has shown the existence of an intimate relation between the precipitation of the copper and the peroxidation of the ferrous oxide of the augitic constituent of the basic rocks; a relation so constant as to render irresistible the conclusion that in this ferrous oxide is to be found the precipitating agent of the copper. To this I would add that the ferrous oxide of the magnetite, and of the unindividualized magma of the vesicular layers, has also been concerned in this re-action.

The home or source of the copper, and the cause of arrest in veins or beds.

Theories of precipitation,

While this explanation of the precipitation of the copper seems satisfactory, we have too little to go upon in deciding between the two views above referred to as to the source of the metal. Too few signs have been observed of the existence of copper in the upper sandstones of the series, such as would be expected were this its home, to allow of an easy acquiescence in Pumpelly's view. On the other hand, the trappean rocks themselves are for the most part devoid of copper, except such as is plainly secondary. Copper in a sulphuretted form I have however observed in the coarse gabbros of Duluth, in the green uralitic gabbro of Mount Bohemia, and in similar coarse rocks in one or two places on the north shore of Lake Superior. It is commonly said that copper occurs in the conglomerates and sandstones only where it could have leached directly downwards from an overlying trappean mass; and with one exception the statement is undoubtedly correct. The exception is that of the Nonesuch cupriferous sandstone, which is however a very important exception, since this rock not only has no overlying diabase, but is separated from the nearest trappean flow beneath it by many hundred feet of detrital material. As previously shown, this sandstone is unusual for its large proportion of basic detritus. Its copper can only be connected with a trappean source by supposing it to have formed part of this detritus in the sulphuretted condition, and afterwards to have been dissolved and re-deposited in a native state. This is a supposition which would seem on the whole however to be rather more violent than to regard the copper as having come from the

and objections to them.

¹⁷Geology of Michigan, vol. 1, part III. p. 43.

overlying sandstones, and as having been arrested in its descent on meeting a layer so rich in basic detritus as to be able to furnish the requisite supply of precipitating agent.

RULES TO GUIDE THE EXPLORER.

Rule for the explorer in rocks of the Keweenaw Series.

Transverse veins.

Cupriferous belts.

Sandstone and conglomerate deposits.

"From the facts and theoretical considerations thus given may be formulated a few simple rules to guide the explorer for copper in the regions traversed by the Keweenaw Series. Thus the explorer, should he be searching for transverse veins, should bear in mind that epidote, prehnite and chlorite are the favorite associates of the copper; that veins carrying a greatly predominating quantity of calcite are not likely to be cupriferous; that laumontitic veins have hitherto not proved to be sufficiently rich for exploitation; that a vein which may be very rich and wide in the amygdaloidal or other soft and easily decomposed rocks will pinch to a mere seam and become barren within the massive and more compact layers; that hence the intersection of a vein with such amygdaloidal or other soft beds should always be searched for; that the copper occurs in these veins with extreme irregularity; and finally, that a vein found traversing decomposed amygdaloid beds with the favorable veinstone, even though it show only a little copper at surface, is worthy of examination.

Should our explorer be looking for cupriferous belts, he should see that they are well defined; that they present evidence of much alteration such as is above indicated, and that one or more of the favorite associate minerals of the copper are present. These favorable indications, along with a more or less well-preserved amygdaloidal character to the rock, and the presence of some copper at surface, are sufficient to warrant further examination. In searching for these belts care should be taken not to be misled by the occurrence of seams of native copper without veinstone along the joint cracks of an unaltered massive diabase, and of isolated pockets of epidotic and calcitic material carrying some copper.

In the case of sandstone and conglomerate deposits the explorer is to bear in mind that thus far they have been found only where a thin seam of conglomerate is directly overlain by a trappean mass: or if away altogether from the trappean beds, only in sandstone which is very rich in basic detritus. Beyond this, there is nothing to guide him except the finding of the copper itself. Any one of the numerous conglomerate seams which from Keweenaw Point to Minnesota are everywhere interbedded with the prevailing basic flow might become cupriferous at any point along its course.¹

¹ The Copper-bearing Rocks of Lake Superior. pp. 419-27.

IV.

ACTINOLITE, ASBESTOS AND TALC.

In one of the earliest records we have of the generations of the heaven and the earth, we are told that every living creature was brought unto the man to see what he would call them, and that he gave names to all cattle, to the fowl of the air and to the beast of the field: "Whatsoever the man called every living creature, that was the name thereof." The first step of wisdom, Linnaeus says, is to know natural bodies, and to be able by those marks imprinted on them by nature to distinguish them from each other, and to affix to every object its proper name. "These," he wrote, "are the elements of all science: this is the great alphabet of nature: for if the name be lost, the knowledge of the object is lost also; and without these the student will seek in vain for the means to investigate the hidden treasures of nature." But however it may have been with the first man, all of us will agree that the knowing of things so as to name them is no simple or modest acquirement. "All things are not within the immediate reach of human capacity," to quote Linnaeus again. "Many have been made known to us, of which those who went before us were ignorant; many we have heard of, but know not what they are; and many must remain for the diligence of future ages." How true this is one has only to study the great Swede's own System of Nature in the light of modern science. We smile at the doctrine that the water of the ocean teems with a double offspring, a saline male and a terrene female; that nitre, muria, natrum and alum are the fathers, and that clay, sand, soil and calx are the mothers of stones; that clay is the earth of marine water, and sand the earth of rain water. We might smile also at the theory that clay, "after remaining a long time dry and compressed is hardened into rasile talc, which by resolution is often regenerated into fibrous asbestos, but when minutely resolved is in a wonderful manner reproduced into scaly mica"; but I fear we know as little of the genesis of these minerals as did Linnaeus himself. Of their exact composition and structure we know much more, for chemical analysis and the microscope have added largely to our knowledge of rocks and minerals during the last fifty years. We know also that, under conditions, changes go on within rocks almost as complex and delicate as in a living organism, begetting little interchanges in the chemical composition and molecular arrangement of the component minerals which may introduce entirely new qualities, or may alter completely their structural form as it appears to the eye. Limestone, chalk and lithographic stone are each of them almost pure carbonate of lime; yet their natural qualities are widely different, and they look as unlike as three distinct races of men. But we have a more striking illustration in the minerals which are the subject of this paper. Actinolite, asbestos and talc are very largely made up of the same elementary substances, and the first and second very nearly in the same combinations. A fourth mineral, chrysotile, is so like asbestos as to be commonly

Identity by
classification
and name.

Constituents
of actinolite,
asbestos,
chrysotile
and talc.

mistaken for it ; so commonly indeed that in commerce and the arts the bulk of what is sold and used as asbestos is chrysotile, or perhaps it would be more correct to say chrysotile with adulterants of actinolite and talc. To show how closely related these four minerals are, I subjoin a table of average constituents computed from Dana :

ANALYSES OF MINERALS.

	Actino- lite.	Asbestos.	Chryso- tile.	Talc.
Silica	57.13	57.82	43.56	61.95
Alumina	1.15	.43	.52	.98
Ferrous oxide	6.39	5.23	1.60	1.91
Manganese oxide .....	.65	.66		
Magnesia	20.66	21.86	41.36	30.87
Lime	13.28	13.98		
Water	1.57	.77	13.79	4.08
Totals	100.83	100.75	100.83	99.79

Similarities
and diversities
in component
parts and
crystalliza-
tion.

The composition of actinolite in this table is an average of eleven analyses, asbestos of six, chrysotile of five, and talc of forty ; and the constituents of each may be therefore taken as standard. Actinolite and asbestos, it will be seen, contain two minerals which are wanting in chrysotile and talc. These are lime and manganese oxide, the former of which is nearly fourteen per cent. of the whole and the latter only little over half of one per cent. Between actinolite and asbestos also the average combinations are so nearly similar that less diversity occurs between them than between individual specimens of each other. It is only in the protoxides of iron and manganese that the differences are more than one per cent.—actinolite having 1.16 more of the ferrous oxide than asbestos, and asbestos 1.20 more of the manganese oxide than actinolite. Both indeed are but different forms of amphibole or hornblende, or that variety of it which contains little or no alumina. When the crystals of the mineral are in radiating masses or long slender prisms we call it actinolite, and when in long, fine, flexible fibres, easily separable by the fingers, we call it asbestos ; but other forms are known as tremolite, nephrite, antholite, richterite, cummingtonite, dannemorite and grunerite, each of which graduates more or less towards asbestos, showing fibrous structure. Chrysotile, which is so like asbestos, is widely different in composition, having 14.26 per cent. less silica and 3.63 per cent. less ferrous oxide, but 19.4 per cent. more magnesia and 13 per cent. more water. It belongs to the serpentine group of rocks, and like all these it contains a high percentage of water. This it is which makes chrysotile less capable of resisting the action of fire than true asbestos, for when the water of crystallization is driven off by heat the fibre becomes hard and brittle. The true fibre, it is claimed, will easily stand a temperature of 2,000 to 3,000 degrees F, and on the best qualities a temperature of 5,000 degrees will produce no visible effect. Talc contains four per cent. more silica than asbestos and nine per cent. more magnesia, but not one third as much water as chry-

sotile. Like these minerals it is low in alumina, and in ferrous oxide it is about the same as chrysotile. It is found foliated, fibrous and massive, and in some of its forms it can hardly be distinguished from corresponding forms of actinolite, asbestos and serpentine.

With these general observations, I pass on to notice some particulars of the three minerals with which I am dealing, where they are found in Ontario, and what uses are made of them.

ACTINOLITE.

A section of country in the counties of Hastings and Addington, embracing the townships of Hungerford, Elzevir, Kaladar and Grimsthorpe, is traversed for many miles by a band of serpentine or magnesite in which are found at frequent intervals bodies or veins of actinolite, and perhaps also of talc. Fibrous serpentine occurs too, as well as fibrous hornblende, although the name actinolite is used generally to describe fibrous or non-fibrous mineral possessing refractory qualities. No deep mining has yet been attempted in this district, the practice pursued being to sink pits to a depth of twenty-five or thirty feet where the mineral outcrops at the surface, and when it cannot be raised without the help of costly machinery the pit is abandoned and a new opening made. This work is carried on for the most part by farmers on their own lots, and in the winter or whenever a favorable opportunity offers loads of the mineral are drawn to the mill at Bridgewater. This mill was built in 1883, and the owners of it have also carried on mining upon their own account. Last year two properties were worked in Elzevir, about three miles from Bridgewater, but not having seen these I am unable to describe either the mineral itself or the formation which contains it.

Areas of actinolite in Hastings and Addington.

PROPERTIES IN ELZEVIR.

In November I visited three properties about ten miles north-east of Bridgewater, near the line of the old Flinton road. This road follows close to the Scootamata river, and for half its way crosses and re-crosses a band of gray gneiss which traverses the country in an east-northeast and west-south-west direction. At lots 7 and 8 in the eleventh concession of Elzevir the gneiss is succeeded by a band of conglomerate, and this in its turn by one of serpentine, parallel to the gneiss. The serpentine forms a series of ridges with narrow valleys between, running with the course of the formation. On the northern side it is cut by two dykes of felspar or pegmatite fifteen to twenty feet in thickness, while about 200 yards towards the south parallel dykes appear. The second of the dykes on the western side, which is the best exposed, dips southeast at an angle of 80°. Beyond it the serpentine is in alternate bands of red and green, and holding small starlike crystals of actinolite. Much of this serpentine is of a fibrous character, and several openings made on the property prove the existence of one or more veins of a distinctly fibrous mineral, the characteristics of which will be described farther on. A quantity of mineral was raised on these lots several years ago and taken to the mill at Bridgewater. They are now owned by The Standard Asbestos Company of New York, of which ex-Governor Campbell of Ohio is

Geological formation.

Standard Asbestos Company's exploratory work.

president, and last year development work of a promising character was carried on under the management of Mr. J. E. Harrison of Bridgewater. A shaft of eleven feet square was sunk on lot 8 to a depth of forty feet, and about 475 tons of fibrous mineral raised. The vein at the surface was only four feet in width, but it widened gradually as the work of deepening proceeded until at about ten feet it was the full width of the shaft. No cross-cutting has been made to ascertain its width at the bottom, and one side of the shaft having followed the hanging wall (which is beautifully slickensided), the opposite side is in the mineral. Reddish colored bands cut across the vein horizontally at intervals of three or four feet, caused probably by infiltrations of iron through seams in the mineral, but which do not appear to have altered its character in any other respect. The quality has continued to improve with the depth, fibres at the bottom of the shaft being about three-quarters of an inch in length. In color the mineral in place is dark green, but after exposure to the air it becomes white, or a pale greenish white.

PROPERTIES IN KALADAR.

Exploratory
work by a
Gouverneur
syndicate.

On the adjoining lot in Kaladar, 8 in the first concession, a syndicate of capitalists in Gouverneur, N. Y., who have had large experience in mining and milling talc at that place, have been doing some prospecting work. They have obtained a lease of the mining rights from the owner of the farm, Mr. D. H. Smith, and have opened several pits upon it. The formation is the same as in Elzevir, and no doubt is a continuation of the same band of serpentine. The stellar crystals of actinolite are distinctly seen in the walls of the openings, gradually thinning out on both sides. The pits however were filled with water, so that I could not observe the character of the mineral at the bottom; but I was informed by the manager of the syndicate, Mr. Whitney, that it opens on a vein twenty feet wide. Mr. Whitney claims that there are three parallel veins on this property. He has also secured for the syndicate several other good locations in Elzevir and Kaladar, and it is proposed to continue development work throughout the present year, or until the extent of mineral on the locations is fully proven.

A large out-
cropping on
Stony creek.

I visited also lot 12 in the second concession of Kaladar, the farm of Mr. George Peebles, where there is a fine and large outcropping of actinolite. It appears to be on a continuation of the same serpentine belt, which here pursues a north-easterly course, and beside it on the west is a band of conglomerate similar to the one which crosses lot 8 in the eleventh of Elzevir. A long and high dyke of pegmatite lies parallel with the vein of actinolite on the east, but separated from it by a narrow band of serpentine. The width of the vein is about twenty five feet, and for some distance it forms the left bank of Stony creek, which here flows swiftly down through a gorge whose walls of rock are fifty feet high and almost perpendicular. No mining has been done on this property, although the situation is favorable for taking out mineral at very low cost. The discovery was made about twenty years ago by Mr. J. E. Harrison, who holds a half interest in it.

THE BRIDGEWATER MILL.

The mill at Bridgewater for grinding actinolite and other fibrous minerals was built in 1883, and for six or seven years the value of its product was about \$6,000 per annum. A dispute between the owners however caused it to lie idle for four years; but their rights having at last been settled in the courts, work was resumed last year. The rock is first crushed in a breaker and then reduced to dust in a pulverizer, but not so fine as to destroy the fibre. Most of the product is shipped in a dry state, but some of it is prepared for roofing material by mixing it with tar. The proportion is eleven gallons of tar to 100 lb. of ground mineral, but pitch or asphalt may be used instead of tar. It is claimed for this roofing that it never gets hard, that heat or cold does not affect it, and that it is fire-proof. The same composition is also used for sidewalks and the foundations of buildings. Uses of actinolite.

ASBESTOS.

In offering any remarks on asbestos, one is perplexed with the doubt if the thing itself exists as the authorities have defined and described it for us. We have fibrous pyroxene, fibrous hornblende, fibrous serpentine and fibrous talc, and by one person or another each of these has been called asbestos.

DEFINITIONS OF THE MINERAL.

Sterry Hunt wrote: "Amphibole assumes fibrous forms as in tremolite, and is often radiated as in actinolite, passing into the soft, flexible, silky variety which constitutes true asbestos or amianthus."¹ Sterry Hunt.

Dana says: "Pliny supposed it a vegetable product, although good for making incombustible cloth, as he states. The amianthus of the Greeks and Latins was the same thing; the word meaning undefiled, and alluding to the ease of cleaning the cloth by throwing it into the fire. The colors vary from white to green and wood-brown. The name amianthus is now applied usually to the finer and more silky kinds. Much that is so called is chrysotile, or fibrous serpentine, it containing 12 to 14 p. c. of water."² Dana.

Professor Chapman, in describing amphibole, says: "The greenish white and colorless or pale gray varieties of this mineral are usually known as tremolite; the bright green, or dark green, acicular and fibrous varieties as actinolite; and the green massive varieties, as well as those in green, brown or black, thick crystals, are commonly termed hornblende, a name applied by many authors to the species generally. A soft silky variety in fibrous masses, belonging however partly to pyroxene, is also known as asbestos or amianthus, but this variety does not appear to occur in Canada, our so-called asbestos being a fibrous serpentine, containing about 12 or 14 per cent. of water."³ Chapman.

Rutley says: "Asbestos or amianthus is a fibrous variety of pyroxene occurring in white silky fibres, which are matted together, but are easily separable. Byssolite is more compact in aggregation, the fibres are coarser as a" Rutley.

¹ Systematic Mineralogy, p. 250.

² System of Mineralogy, sixth ed., p. 234.

³ The Minerals and Geology of Central Canada, third ed. p. 102.

rule and are not easily separated, the structure more resembling that of wood, while the color is usually dark green or greenish gray. It may be regarded as an iron-manganese amphibole."⁴

Day. Dr. Day of Washington says: "The fibres of asbestos are short and brittle, while those of chrysotile are flexible, slightly elastic, and of great tensile strength."⁵

Ells. Dr. Ells of the Canadian Geological Survey says: "What is known as the Quebec asbestos of commerce and the true asbestos are two distinct substances, and belong to two distinct groups of minerals. Thus asbestos proper belongs to what is known as the pyroxene or hornblende group, while that obtained from the Quebec mines belongs to the talc or serpentine group. The former is classed among the igneous rocks proper, such as syenites, granites, porphyries, etc., and embraces among other varieties augite, diallage, hornblende, etc. Some asbestiform minerals are augitic, but the greater number belong to the hornblende family, and are known by several names, such as amianthus, asbestos, byssolite, tremolite, actinolite."⁶ Dr. Ells also says that among the most important of the properties of asbestos is its non-conductivity, or power of resisting the action of heat, in which respect it possesses some of the properties of wood, but does not, like wood, char or ignite under friction, no matter how long it may be applied. "This property of non-conductivity," he says, "or of resistance to fire or heat, is one of the principal reasons for its extensive application in certain lines at the present day."

Klein. Mr. Klein, M. E., of Black Lake, Q., says: "Asbestos is a fibrous variety of serpentine, and is, chemically speaking, a hydrous silicate of magnesia. From several analyses of a number of specimens all over the world, which I had at my disposal, the percentage of silica is from a little over 40 to 40½ per cent., while magnesia is from 41½ to 43 per cent.; other more prominent admixtures were ferrous oxide and alumina in quantities of from 1 to 3 per cent., and further, traces of lime, potash, soda, chlorine and sulphuric acid. This composition is completed by water, to which we have to attach the most importance from a business point of view. This of course is not water in the form of a moisture, but water intimately associated with the silicate of magnesia. The importance of this water has been shown by the fact that good and fine asbestos fibre, may it be from the Italian variety or from the Cambrian rocks of the Eastern Townships, or the Laurentians from the north of the St. Lawrence, contains from 13½ to 14 per cent. of this water, while some very harsh and brittle specimens of asbestos have shown considerably below 12 per cent. Experiments have further shown that it is comparatively easy to dissociate a part of this water from a fine and silky specimen of asbestos fibre, and to render the same hard and brittle by heating it to a certain extent."⁷

⁴ The Study of Rocks, p. 131.

⁵ Mineral Resources of the United States, 1889-90, p. 514.

⁶ Asbestos, its History, Mode of Occurrence and Uses, p. 5.

⁷ Journal of the General Mining Association of the Province of Quebec, vol. I, p. 145.

Professor Donald of Montreal argues that, because the Province of Quebec produces about 85 per cent. of the world's supply, with the balance chiefly from Italy, it is reasonable that these two countries should be allowed to appropriate the name of products which are known all over the world as asbestos, "even though they be of other composition than the mineral to which mineralogists originally applied the term, and that other minerals, if such there be, used for similar purposes be otherwise designated." Concerning its power of resisting the action of fire, he says: "It is true that asbestos is infusible, except at very high temperatures, but it is equally true that only a very moderate degree of heat, heating to low redness in a platinum crucible, for instance, is required to entirely destroy the flexibility of the fibre and render it so brittle that it may be crumbled between thumb and finger as readily as a piece of biscuit. In this connection one is reminded that the ancients are said to have possessed asbestos napkins which they cleansed by means of fire, and that Charlemagne in like manner cleansed his tablecloth, to the delight of his warrior guests. It is not improbable that these statements are to a large extent mythical; certainly, if true, the articles in question were not made of asbestos, the hydrated magnesian silicate." And on the non-conductive property of the mineral he says: "The truth is that asbestos itself is a very poor non-conductor, as anyone may prove by placing a vessel of water on a sheet of asbestos cardboard and applying heat from below, or more simply still by placing a piece of wood on a sheet of asbestos millboard on a hot stove. . . . The use of asbestos in the manufacture of non-conducting coverings for boilers, etc., is due to its fibrous texture and its infusibility. The latter property gives it a decided advantage over hair and other fibrous materials, which char under continued exposure to heat, while the exceeding flexibility of its fibres gives it a like decided advantage over mineral wool and other fibrous but brittle mineral substances."⁸ And replying to criticisms on his views at a later date, Prof. Donald says: "I am quite willing to admit that a napkin, if made of fibrous hornblende, is practically uninjured by fire; my scepticism is as to these ancient napkins being made of fibrous hornblende. I wish to know where hornblende, having fibres so fine and flexible that they may be spun and woven, is to be found."⁹

And J. Lainson Wills of Ottawa says: "The chemical qualities and physical properties of the respective amphibole group and serpentine group of asbestiform minerals are well marked and characteristic, affording a positive basis for nomenclature and classification, and allowing no arbitrary liberty as regards its correct mineralogical appellation. Let us by all means conserve the name of asbestos as originally applied to the amphibole variety, and if employed generically, the attributes of serpentinous and hornblendic, or simply serpentine-asbestos and hornblende-asbestos might be adopted. If a chemical analysis shows a product cannot thus be classified, then we are in presence of a new mineral, requiring investigation."¹⁰

⁸ The Engineering and Mining Journal, March 18, 1893.

⁹ Ibid., April 1, 1893.

¹⁰ Ibid., July 22, 1893.

Asbestos of
the ancients.

This last observation of Mr. Wills is well taken, and I am not sure but we may have at least one new mineral of the fibrous variety to investigate and name. But perhaps if we knew more about the asbestos of the ancients, and the actual tests to which it was subjected by them, there might be no sufficient ground for the differences of our modern doctors. We do not believe everything that we read in Greek story, and the amianthus shroud may be only one of the many Greek myths. The asbestos of the ancients may have been nothing else than fibrous serpentine, like that of Italy or Quebec. If it was fibrous hornblende, which could be woven into shrouds and napkins, why cannot it be produced at the present day? I do not know of its being found in any country of Europe, and I do not believe that it has yet been discovered in America. Fibrous hornblende we have, but the fibre is neither long, nor silky, nor flexible. How then can it be spun into thread, or woven into cloth? It may be used as a filling with the serpentine fibre, and I have no doubt that it is so used, and to good purpose; for the quality of the goods is likely to be improved by the addition of material which further enables it to withstand the effects of heat. But there are uses of asbestos where strength is the first requirement, and in the manufacture of this class of goods all long fibre would seem to be indispensable.¹¹

¹¹ In 1886 a paper was read before the Society of Arts in London, Eng., by Mr. James Boyd of the United Asbestos Co., which elicited warm praise from Sir Frederick Abel, Prof. Warrington Smythe and other members of the Society. Mr. Boyd had spent much time in the asbestos mines of Italy, where his Company owned valuable properties, and he was able to give many interesting particulars of the occurrence of the mineral and the mode of mining it, as well as of the subsequent treatment. There are three distinct varieties found in that country, viz., the gray, which has a long, strong fibre, and is saponaceous to the touch; the flossy, which has a smooth, silky appearance, but is dry to the touch; and asbestos powder, which, while possessing all the heat resisting properties of the preceding, crumbles into powder when crushed. The first of these is found principally in two Alpine valleys, the Valtellina and the Valley of Aosta, and the mines are at elevations ranging from 5,000 to 8,000 feet above sea level. Mining operations are expensive, owing not only to the situation, but also to the thin and irregular nature of the seams, which makes necessary the doing of a large amount of dead-work. As the result of long observation on his own part and on that of the Company's Italian employes, Mr. Boyd presented in his paper the following conclusions:

"1. That asbestos of good quality is only to be found in the serpentine formation. A fine seam of asbestos was found four years ago in a quartz formation which seemed to upset this conclusion, but it proved just as we suspected, that the quartz was only superficial, and before six feet of rock had been blasted away the serpentine began to crop through.

"2. That if asbestos be found on the face of a rock exposed either to the south or west, the product is generally fairly abundant and of good quality. If exposed to the east, there is fine quality but very small quantity, whilst if exposed to the north the quantity is plentiful but dry and hard, and on entering into the rock all traces of it are lost."

Another statement made by Mr. Boyd, which may be useful to prospectors, relates to the signs of the mineral where there is no proper exposure of it. "When asbestos is first found in any new place, generally the only superficial indication is that the cracks in the rocks are filled with a white powdery substance. When the surface is broken up this usually changes into a leathery-looking substance, and entering still further the true asbestos fibre may be found." But sometimes even in Italy the practice of "salting" is resorted to, which consists in "driving in fine asbestos fibre into the cracks of the rock, and trying to make it look like real formation." Mr. Boyd appears to think that this is a peculiarly American practice, and he has also discovered that Canadian fibre imported from America in the carded state by his firm was found to be a mixture of asbestos and cotton. Like the chairman of his Company—who stated in the discussion upon the paper that the Italian asbestos was superior to the Canadian in every respect, especially in its capability of being woven into cloth—Mr. Boyd expressed a strong and natural preference for the article produced from his Company's mines. "Each have their advocates and partisans," he said, "but I do not consider the present a fitting occasion to deal with this question, and I therefore limit myself to saying that whilst for certain uses the one may be as suitable as the other, it is not so in all cases. As an examination of the samples will show, the Italian is long and strong in its fibre, and is saponaceous to the touch, whilst the Canadian is short, and to the touch is as dry as chalk; and therefore it seems to me that the properties of Italian indicate it as better suited for the engineer's use, especially in the form of packing or jointing." Mr. Boyd confessed that with the formation and working of Canadian asbestos he had no practical experience, and that his remarks were based upon data furnished by Mr. Irwin of the Anglo-Can-

THE SOURCES OF SUPPLY.

The sources of supply are not numerous, and at present they are almost wholly confined to Quebec and Italy. The Quebec mines at Thetford and Black Lake, in the Eastern Townships, yield an excellent article which finds a market in Great Britain and the United States. About \$3,500,000 are invested in the industry, which employs about 2,000 men. In 1880 the output of the mines was 380 tons, valued at \$24,700; but in 1890 this was increased to 9,860 tons, valued at \$1,200,240. The following table, showing the comparison of Canadian with Italian asbestos, is taken from a paper by Prof. Donald, read at a meeting of the Quebec Mining Association;¹² but for further comparison I have added the average computed from Dana:

Constituents.	Italian.	Broughton.	Templeton.	Dana.
Silica	40.30	40.57	40.52	43.56
Magnesia	43.37	41.50	42.05	41.36
Ferrous oxide .....	.87	2.81	1.97	1.60
Alumina	2.27	.90	2.10	.52
Water	13.72	13.55	13.46	13.79
Total	100.53	99.33	100.10	100.83

Analyses of
Italian and
Quebec
asbestos.

The chief difference is that the Quebec asbestos is higher in iron, but lower in alumina, than the Italian; and compared with Dana's average it is three per cent. lower in silica, but higher in ferrous oxide and alumina.

In Ontario fine samples are sometimes found by prospectors, but most of them are believed to have been brought from Quebec. There is however one genuine location in the township of Marmora, upon which a little work has been done by the present owners, the North American Stone and Asbestos Company of New York. It is the chrysotile variety, and the fibres are very short, not exceeding one-third of an inch. Possibly longer fibre may be found when the vein is properly opened. Another location I have described already, the one on lots 7 and 8 in the eleventh concession of Elzevir, owned by the Standard Asbestos Company. But I hesitate to call the mineral asbestos. I think it might puzzle the doctors to find the right classification, and possibly they may have to get a new name for it. I have submitted a sample to Prof. Coleman, of the School of Practical Science, who has fur-

Ontario
samples.

Mineral of the
Standard
Asbestos
Company.

dian Asbestos Company. Mr. Irwin himself at a meeting of the Mining Association of Quebec in April, 1891, stated that there is very little difference between the Canadian and Italian asbestos as to their composition, but there is a very great difference in their formation. "The Italian asbestos is exceedingly long in fibre, but it is in such a shape that it is almost impossible to handle it properly with machinery, while Canadian asbestos costs so much less to manipulate, and allows it to be placed in the market in its manufactured shape at a price that will enable it to compete with any other asbestos material." And Prof. Donald in remarking upon the attempts which had been made to decry the Canadian article, and to prejudice users by the statement that chemical analysis showed the latter to be inferior to the Italian, was able to show by analysis that the "Canadian fibre is in no wise inferior to its European rival." As to harshness, he pointed out that it was due to a lower percentage of water. "In fibre of very fine quality from Black Lake, analysis showed 14.38 per cent. of water, whilst a harsh-fibred sample gave only 11.70 per cent." See Journal of the Society of Arts, April 16, 1886, and Journal of the General Mining Association of Quebec, vol. 1, pp. 27-29.

¹² Journal of the Association, vol. v, p. 27.

nished me with an analysis. But as for the name, he is discreet and describes it by the phrase "asbestiform mineral." That is good so far, but doubtless the Professor will follow it farther and find a name or make one.¹³ The analysis shows it to consist of 61.82 silica, 23.98 magnesia, 6.55 ferrous oxide, 1.63 lime, 1.12 alumina, and 5.45 water. Compared with the Dana average of hornblende asbestos, it has 4 per cent. more silica, 2.12 more of magnesia, 1.32 of ferrous oxide, 4.68 of water, and .69 of alumina; but 12.35 less lime and no manganese oxide. Compared with the average of serpentine asbestos, it has 18.26 more silica, 4.95 of ferrous oxide, and .60 of alumina; but 17.38 less of magnesia, and 3.34 of water, with lime additional. Compared with the average of talc it has almost exactly the same proportion of silica and alumina, but 4.64 more of ferrous oxide, and 1.37 of water, with lime additional. The fact that calcite is found mixed with the serpentine which forms the walls of the vein will doubtless account for the presence of lime in the mineral. Some of the fibre is nearly an inch long, and is white and strong, but harsh to the touch. The crystals however are so crossed and interwoven that it will be difficult to separate the fibre from the matrix without a large percentage of loss; it is large in Quebec, where in crushing with stone the long and most valuable fibre is partially destroyed; but a suitable treatment may be found. A shipment of 100 tons has been made to the Company's mill at Elizabeth, N.J., to be tested by a new plant which has been put in for the purpose. A smaller shipment has also been made to one of the talc mills at Gouverneur.

Production of
asbestos in
the United
States.

In the United States the production of asbestos has shown a constant decrease since 1882. The product of that year was 1,200 tons, but in 1885 it fell to 300 tons, and in 1889 the only asbestos mined in the country was 30 tons raised in California. In 1892 it had increased to 104 tons, whereof California again produced 30 tons. This is a curious commentary on the accounts of mineral wealth which occasionally find their way into scientific periodicals. A wonderful discovery of asbestos in California was reported in the Journal of the Society of Arts five years ago. "The vein is about twenty-five feet in thickness, and has been proved to extend for a distance of 1,500

¹³ Dr. Coleman has made a further study of this mineral, which he describes as consisting chiefly of irregular bundles of a strong, fibrous mineral resembling chrysotile mixed with a dull green one like serpentine, the two passing into one another. "The serpentine mineral has evidently been formed from enstatite, since it encloses at one or two places remnants of that mineral on which it has encroached. Small amounts of pale green fibrous talc are mixed with the tough fibrous mineral, and the talc sometimes occurs in small masses by itself. In addition, one finds portions of carbonates, partly effervescing with cold dilute acid, and hence calcite; partly dolomite, or perhaps a related carbonate." And commenting upon the chemical composition of the mineral he says: "The results of the analyses correspond quite closely with the composition of enstatite, supposing its constituents to be rearranged and hydrated. They come less close to the orthorhombic amphiboles, such as anthrophyllite, showing too little silica and iron, and too much magnesia and water; and they differ widely from chrysotile, having far too much silica and far too little combined water and magnesia. In physical characters however the resemblance between this fibrous mineral and chrysotile is very close. They are indistinguishable under the microscope, having the same silky fibres and parallel or almost parallel extinction. . . . It seems to correspond most nearly in chemical composition to some of the fibrous forms of monoclinic amphibole, *e. g.* antholite or kuppferite. The analyses given of the latter mineral differ but little from those made by the writer; but the last edition of Dana's Mineralogy drops the name entirely, and gives antholite only a very brief reference. Probably if it is to be referred to any species beyond the broad one of 'fibrous amphibole containing little or no alumina,' the name antholite is the most appropriate. The amount of combined water, which varies however in different samples, seems the only objection to such a reference."

feet, and is traceable for nearly three-quarters of a mile by croppings that occasionally come to the surface. Unlike many other asbestos deposits, this vein is almost unmixed with hornblende and tremolite. The fibres are long, silky and of a beautiful pearly lustre. The fibres are as tough as flax, and are capable of being spun into a fine thread. . . . In the same vein there appears to be an inexhaustible quantity of ordinary abestos, such as is used for covering steam pipes, etc. The true amianthus is found in veins from one to four feet in thickness, and can be pulled out with the naked hands in tufts upwards of three feet in length."¹⁴ And yet with this wonderful vein to draw upon, the manufacturers of asbestos goods in the United States continue to get almost all their raw material from the Province of Quebec. But this is not the only instance in which British scientific periodicals have been used to boom properties in the United States and elsewhere. It is now said that development work is being carried on in Wyoming, where veins and pockets are reported to be numerous, varying in width from a few inches to four feet. Some of the fibres too are claimed to be over forty inches in length.¹⁵

MANUFACTURE OF ASBESTOS GOODS.

The manufacture of asbestos goods has developed into an important industry within the last ten years, and large establishments are employed in Great Britain and the United States. It might be interesting to describe the process by which the raw material is rolled and stirred and boiled to separate the fibre from its matrix, and how the short and long fibres are sorted; but this must be passed over. The goods into which the fibre is made up are various, and of important uses. Among these are building and lining papers, waterproof sheetings, fireproof papers, steam packing, steam pump and boiler coverings, firemen's clothing, blacksmiths' aprons, theatre curtains, lamp wicks, etc., for all of which it combines in a high degree the qualities of durability and safety. One factory at Erie, Pennsylvania, consumes 80 tons of asbestos per day.

British and
American
manufactures.

TALC.

I come now to talc, of which there are several varieties; but the principal ones are the fibrous, the foliated and the massive. These three are found in Ontario, but the largest known veins are in the counties of Hastings and Addington. Massive talc or steatite occurs in various parts of Kaladar and Elzevir, and no doubt the fibrous is found there also. The foliated has been discovered in Grimsthorpe, where there are some veins of large size. Talc has also been found in East Algoma, near the Sault branch of the Canadian Pacific Railway.

Varieties of
talc.

PROPERTIES IN ELZEVIR AND KALADAR.

Mr. D. J. Whitney of Gouverneur, N.Y., who carried on an extensive marble business in that place for twenty-five years, and who five years ago opened up marble properties at Madoc, is now interesting himself in develop-

¹⁴ Journal of the Society of Arts, December 21, 1888.

¹⁵ Mineral Industries of the United States, 11th Census, p. 730.

The talc industry at Gouverneur, New York.

ing fibrous talc properties in the townships of Elzevir and Kaladar. In the course of a conversation he gave me many interesting particulars of the talc industry as carried on at Gouverneur, and outlined a project on the part of himself and associates to utilize properties recently acquired by them in the townships above named. Until a short time ago there were six firms or companies engaged in the business at Gouverneur, but four of these have sold their interests to a syndicate composed principally of New York Central men, including William Walter Webb and Chauncey Depew. It is also believed that the Vanderbilts hold a large block of the stock. The price paid for the properties was about \$1,000,000, but the syndicate has organized with a capital of \$2,000,000 preferred and \$3,000,000 ordinary stock—the latter to get no share of earnings until the former has been paid ten per cent. Since this syndicate has entered into possession, the New York Central has secured control of the Rome, Watertown and Ogdensburg road, and branches have been built to all the mines and mills, thus greatly facilitating the working of the mines, but at the cost of displacing \$100,000 of labor for teaming every year. The two other concerns refused to accept the terms offered them, and to the extent of their ability to compete with the stronger corporation, monopoly is held in check.

The rock formations at Gouverneur are similar to those of Elzevir and Kaladar, but as they are extensively covered with drift the task of prospecting them is one of much greater difficulty. Rocky ranges outcrop in places, but exploring has sometimes to be carried on by pits and cross-cuttings through the drift. As a consequence, when mineral is discovered and a shaft sunk upon it, tunnels are carried on for long distances—from a quarter to half a mile. Some of the shafts have been put down to a depth of 300 feet or over, but it does not appear that even at this depth bottom has been reached.

The mineral occurs in large pockets or lenses, which thin out at the edges to the vanishing point, but by following on the show new bodies of similar form are almost always discovered. It is either soapstone or talc, some portions of which are slightly fibrous and nearly all of it white; but according to Mr. Whitney none of it contains the long, fibrous crystals which constitute the chief portion of the Ontario mineral.

The rock is ground either in a cyclone pulverizer, or in cylinders holding flint nodules, which by attrition reduce a charge of 1,500 lb. to the consistence of flour in a few hours.

Uses of the mineral.

The foliated talc, which is found in some places, is in little request, but it is quite suitable as filling for wall paper. The fibrous and non-fibrous or massive varieties are about equally valuable as filling for printing paper, to which it gives weight and strength, especially the fibrous material. Formerly French clay was chiefly used for this purpose, but not more than thirty per cent. of it is retained in the pulp, whereas seventy-five or eighty per cent. of the talc is so retained. The foliated talc, no matter how finely it may be

ground, maintains its scalelike form, and it is found that printing paper containing it scales off in the press and fills up the face of the type, so that a clear impression cannot be got.¹⁶

The ground talc is used as an adulterant in many ways, such as in the manufacture of paint and asbestos, and sometimes it is even added to flour; but, as in the case of all other adulterants, the users of it are careful to conceal the fact. One asbestos manufacturing concern receives three or four car loads per week of ground fibrous talc from the Gouverneur mills, and no doubt it is used in the production of asbestos goods. Mr. Whitney also says that twenty-five tons per week of the finer grade is shipped to Canada as French clay and sold to the paper mills; but this statement does not appear to be confirmed by the Government trade tables.¹⁷

The fibrous mineral of Ontario may be utilized for all the purposes of the Gouverneur article, but the long fibre will be much more valuable for the asbestos trade. By sifting, the several grades may be easily separated—the finer qualities to be sold to the paper, and the coarser or more fibrous to the asbestos manufacturers. The Gouverneur product is in part exported to Europe, but the Canadian will have an advantage in furnishing a better article, and possibly in securing cheaper rates of delivery to the seaboard. It may also find favor in the United States, owing to its wider range of qualities.

The four concerns which have sold out to the New York Central syndicate, along with Mr. Whitney and his brother, purpose to engage in the industry in Ontario. They have been taking up properties during the past summer, and some development work has already been done upon them, especially on lot 8 in the first concession of Kaladar, adjoining the property of the Standard Asbestos Company in Elzevir, but they are anxious to prove that the mineral is procurable in sufficient quantity before undertaking the erection of mills to treat it. A plant of suitable capacity will cost about \$100,000, and they are careful not to go into so large an undertaking before knowing that they can depend on the source of supply of the raw material. Fibrous hornblende is also valuable for the same purposes as talc, and Mr. Whitney believes that there are large bodies of it in the district, as well as talc and actinolite.

A New York syndicate exploring in Ontario.

¹⁶ Since this section of the Report was put in type the Berlin School Supply Company has found a new use for talc, viz., as material for the manufacture of school crayons. A suitable variety for this purpose is obtained in the eastern part of the Province, and when cut with saws into convenient size and form it is a superior crayon for the blackboard. It makes a clean white mark on board or slate, does not easily break or crumble into dust, and will out-wear half a dozen of the crayons in common use in the schools. It is being used for the same purpose also in North Carolina.

¹⁷ A peculiarity of the Grimsthorpe foliated talc is that it contains nickel; but it has not yet been discovered that this metal is present in workable quantity. The following analysis of a sample from the property of the Kent Brothers, Kingston, has been furnished to the Bureau by Prof. Nicol, of the Kingston Mining School:

Silica	62.95
Ferrous oxide	2.57
Alumina .....	.85
Magnesia	27.87
Nickel oxide .....	.17
Water	4.75
Total	99.16

THE TALC BELT OF NEW YORK.

Growth of the
talc industry
of New York
State.

In a paper on the Talc Industry of the Gouverneur district, contributed by Axel Sahlin, M.E., of New York, to the Schuylkill Valley meeting of the American Institute of Mining Engineers in October, 1892, that authority describes the talc belt as having a length of eight miles by a width of one mile. "Since 1879," he says, "ten distinct mines have been opened, and some of these have reached a depth of 400 feet or more on the slope. The present output from these ten mines amounts, according to a close estimate, to 51,000 tons per annum, which figure however could be readily doubled if the reducing mills had the capacity to handle the larger quantity. The cost of mining varies from 60 cents to \$1.25 per ton, to which must be added the royalty charged by the land owners, amounting to from 50 cents to \$1.00 per ton of talc raised. The transportation of the rock to the mills by wagon or sleigh, over wretched country roads, costs from \$1.35 to \$1.50 per ton. The total cost of talc rock deposited at the different mills therefore varies from \$2.25 to \$3.75 per ton. . . . About thirteen years ago the first talc mill was started on a modest scale at Gouverneur. Now eight efficient mills produce yearly 50,000 tons of talc, all of which so far has found ready sale without even being advertised. . . . As yet," he concludes, "the talc industry is in its infancy, and hardly known beyond a few localities. When once the fibrous mineral pulp shall have become familiar to the paper trade of the world, it will not be the want of a market, but the scarcity of talc that will regulate and limit the development of the peculiar industry of Gouverneur."¹⁸

With such a promise for the talc industry in a small district of the State of New York, is it not worthy also of receiving a measure of attention in Ontario, where the raw material is believed to exist over a much larger area and in far greater quantity? To know the names of minerals has its value, and our doctors and professors cannot study names too carefully. But what the country most cares for is the minerals themselves, and the best way to win them and convert them from a mere natural resource or possession into tangible and potential wealth.

¹⁸ Trans. Am. Inst. Mining Engineers, vol. XXI, pp. 585-7.

V.

VITRIFIED BRICK FOR STREET PAVEMENTS.

It is often said that the condition of a country's highways is the measure of its progress, yet in this America of ours, where there are many other social and economic anomalies, we have a high degree of civilization existing contemporaneously with very bad roads. The common country road of this continent is as inferior to the ordinary road of Great Britain or of almost any of the countries of continental Europe as are the bridlepaths and mud-filled lanes of China to our own highways. There is a reason for everything, and we may find some compensating advantages in the absence of those military considerations which make good roads a matter of prime importance to the nations of Europe. But the loss to the country at large, and particularly to the farmer, through the bad condition of our country roads, which amounts at certain seasons of the year to absolute impassability, can hardly be estimated.

Roadways of Europe and America.

What good roads are to the rural population, good streets are to the dwellers in towns and cities, but in a higher degree. They are the arteries through which flows the tide of urban life, and it is of the very first consequence that they be made of suitable material and properly constructed.

The problem of life is how to get the greatest possible return for the least possible outlay; and this is true in the realm of mechanics as well as in that of finance. The drawing of a load along a city street is an example of the expenditure of force. The motive power is the horse or other animal, the weight to be moved is the vehicle and its contents, and the roadway supplies the plane in which the motion takes place. The energy exerted by the horse is absorbed in the work of starting the load and keeping it in motion, and this involves the overcoming of what may be called the internal friction of the wagon, viz., the pressure of the axles on the hubs, as well as the inertia of the load itself and the resistance offered to the forward motion of the wheels by the pavement. In proportion to the size and number of the obstacles interposed by the pavement—in other words, in proportion to its roughness—will be the difficulty of moving the load and the amount of resulting wear and tear. It is obvious that this wear and tear will not fall upon the pavement alone. The heavier the task, the greater the strain upon the motive power, viz. the horse. Extra exertion will make him prematurely old and reduce his value. The vehicle, too, comes in for its share. Tires are worn out, spokes and axles are broken, bolts are shaken loose, and the life of the vehicle as well as of the horse is shortened. The effects of the friction are seen in decrepit horses, worn harness and broken wagons, and not alone in ruts and holes in the pavement. Indeed, if a perfectly indestructible material could be got of which to construct our roadways, even at moderate cost, it might

The problem of greatest return for least outlay.

Cost of wear and tear.

be found that such a material would be extremely expensive, were it to present a surface of unusual roughness. From the fact however that the adverse effect upon horses and vehicles is distributed over a large number of private individuals, it is very difficult to estimate this factor in any particular case, or relatively as to the various kinds of pavement. The cost of pavements themselves can be calculated to the last cent, but only an approximation can be made to the expense entailed by wear and tear on horses and wagons. The former is generally defrayed out of the public purse, while the latter falls upon individuals; hence cheapness and durability are usually the particulars most prominently considered when a new pavement is in contemplation. It is plain that the ratio of effect on horses and vehicles must be very much larger in the case of the rougher pavements, such as those made of wooden blocks, granite, and even macadam, than in that of asphalt or brick, which present a surface of so much greater smoothness. Other things being equal, the smoother the pavement the better it is. The question of wear upon horses and carriages in relation to the various kinds of pavement has probably not yet received the attention which it deserves, although it is a very important factor in determining the superiority of one sort over another.

The axiom of good pavements.

THE QUALITY OF ROAD MATERIALS.

Materials of road-making

To the maker of roads and streets a wide choice of materials is open; and accordingly we find him making his selection from the mineral, vegetable and even the animal kingdom. In some of the southern States, for instance, the shells of the oyster are pulverized and spread out in a glistening pavement; and wood of various sorts and in many forms invites use by its cheapness and adaptability. The corduroy of the bush settlements, whose spring-breaking joltiness is preferable only to the mud of the swamps through which it is laid; the plank roads, once common in certain parts of rural Ontario: the cedar blocks of our towns and cities, not to speak of the cubes of real mahogany with which the fastidious rulers of Paris are now said to be ornamenting the streets of that luxurious city at a cost of £2 per square yard,—all testify to the utility of wood for paving purposes.

In rural districts,

But it is naturally to the mineral constituents of the earth's crust, either in raw or manufactured form, that the road builder looks when it is determined that art must be called to the aid of nature. The mud road of the country is tolerable, even comfortable, in summer when the dust does not ride on the wings of the wind; but when the spring or fall rains have converted the clay or soil into a glutinous mass of varying depth, or when the pathmaster has just finished laying on his annual contribution of loose gravel or soft earth, travel becomes difficult and hauling of heavy loads impossible. Gravel roads, such as are found in some parts of western Ontario, when well made and kept in repair afford an agreeable contrast to the ordinary mud roads, and really add largely to the value of the farms in front of which they pass. Broken stone is a step in advance of round gravel, but in this country Macadam numbers few followers outside of towns and cities, and in the latter, macadamized surfaces, though suitable for light traffic,

are falling into disfavor because of their uncleanness and the expense entailed by constant repairs.

For city streets, stone or granite sets, asphalt and vitrified brick are all in use, and each one of these several materials possesses excellent qualities for paving purposes. As compared with wooden blocks, each of them is preferable in almost every particular, except in the important one of cost. and in the cities and towns.

The vast stretches of cedar block pavement which have been laid down in the city of Toronto, for instance, cannot fairly be said to have been successful. On side or residential streets, where the butcher, the baker, the grocer and the milkman provide the bulk of travel, cedar blocks do tolerably well. They are not expensive to lay, repairs are easily made, and where the traffic is light they preserve an even surface for a considerable length of time. But where heavy loads are numerous and travel constant, cedar blocks are altogether out of place. The edges soon wear off, leaving each separate block of a rounded, almost semi-globular form, and producing a surface comparable in roughness to that of a swamp corduroy. The porous nature of the blocks permits them to absorb a very large portion of the liquid filth which falls on the street, and this, added to the dirt, droppings, etc., which lodge in the hollows between the worn blocks and which ordinary street cleaning is powerless to remove, forms a mass of decaying, germ-breeding matter not only offensive to the sight and smell, but injurious to the public health. The life of a cedar block pavement varies somewhat in proportion to the travel over it, but on heavy traffic streets in cities like Toronto it does not exceed four or five years. Where traffic is light another source of decay is in the blocks not being kept constantly moist, but being alternately wet and dry they succumb to rot almost as soon as they would have done to the wear and tear of heavy traffic. Cedar blocks.

The good qualities of a granite pavement are many. It is not indestructible, but it is adamant compared with wooden blocks; and in a list of all the materials used for street paving, so far as time and experience have yet disclosed their relative durability, the first place would probably belong of right to granite. Possessing this prime requisite for paving purposes—high powers of resisting wear—and being comparatively unobjectionable from a sanitary point of view, were granite smooth and inexpensive, one would probably be tempted to look no further for a paving material. There are vast stores of granite in the archæan formations of our own Province, much of it convenient for shipment by water or rail; and in places where dray and freight traffic impose their severe tax upon the resisting qualities of a pavement, granite will probably always remain in use notwithstanding its comparatively high cost. The expensiveness of granite sets is due largely to the amount of labor necessary to properly dress and shape them, an item which cannot be avoided and which is not offset even by our comparative nearness to the places of supply. A granite pavement affords a better foothold for horses, especially in wet or frosty weather, than asphalt, but it is not so smooth, and its adverse effects upon both horses and vehicles is certainly very much greater. Granite.

Asphalt pavement is exquisitely smooth. It offers less resistance to the passage of vehicles than any other pavement known, and is very easily swept and kept clean. From a sanitary point of view it is entirely unobjectionable, Asphalt.

and when made of pure lake asphalt it is durable. Carriages and wagons make little or no noise passing over it, but the clatter of the horses' hoofs is not inconsiderable. The drawbacks to asphalt pavement are its very high cost, its slipperiness, especially when covered with a coating of ice or sleet, and the injury and expense attendant upon disturbing it for repairs to sewers, gas pipes, etc. The asphalt pavement first laid down in the city of Toronto was on that part of Bay street which lies south of King, and after five years' existence it is still in perfect condition, while on many other streets pavements since put down are showing numerous cracks which are rapidly becoming fissures, and other symptoms of wear. There is also a difficulty in making repairs to asphalt pavement, as it is no easy task to fuse the new material with the old, and if this is imperfectly done a weak spot is left to become a centre of disintegration. Another drawback of minor importance is the fact that in cold weather an asphalt pavement cannot well be sprinkled with water to keep down the dust, as a thin coating of ice is immediately formed, troublesome and even dangerous to horses. The life of an asphalt pavement is variously stated, some placing it at from seven to ten years where the traffic is heavy, and from sixteen to twenty years where it is light. There has not as yet been sufficient experience with asphalt in our own climate to judge with accuracy how long it may be expected to last under ordinary conditions, but the figures given above are probably not far from the mark. Very much however, as is evident from the experience of Toronto, depends upon the quality of the material and work.

Brick.

A brick pavement made of good material, properly laid, is almost everything that a pavement should be. It is smooth, ranking in this respect next to asphalt, and consequently offers a minimum amount of resistance to the passage of traffic, and inflicts a minimum of wear and tear upon horses and vehicles. It has the advantage over asphalt that, while it is smooth, the small spaces between the bricks afford a foothold for horses and prevent their slipping. So far as sanitation is concerned, it leaves little to be desired. It can be swept, cleaned and washed with ease, ranking in this respect next to asphalt, and far superior to granite or wood. It has none of the absorptive properties of wood, being nearly as impervious as asphalt and granite, and consequently escapes the odium which attaches to wood pavements of harboring filth and decaying organic matter. No pavement is noiseless, but in this particular brick comes next to asphalt and excels granite, being quite devoid of the "bumpiness" which characterizes the latter. It is easily laid and easily taken up when underground repairs are to be made, being almost as convenient to handle as wooden blocks and quite as much so as granite. The question of the durability of brick pavements is one that has been much discussed, but although American experience in this line has been largely confined to the last ten or twelve years and a final judgment cannot therefore be pronounced, it is everywhere the opinion that in point of durability brick is not excelled by any other material. The first streets paved with brick in America are at Charleston, W. Va., and Bloomington, Ill., where the pavement has been down about twenty years. In the former place it has given "entire satisfaction," and in the latter the verdict is equally favorable. It "gives

universal satisfaction, and stands heavy traffic, showing no signs of wear." At Wheeling, W. Va., where there are twenty miles of brick pavement, the first was laid in 1883. There, too, the city authorities are emphatic in its praise as being economical, durable, sanitary and smooth.

BRICK FOR BUILDINGS AND PAVEMENTS.

As a building material, brick came very early into use. At the dawn of history we find it employed in the erection of large and important structures which were intended to be a lasting memorial of those who built them. It is narrated in the oldest and most trustworthy record of the primal days of man that "The whole earth was of one language and of one speech. And it came to pass, as they journeyed from the east, that they found a plain in the land of Shinar; and they dwelt there. And they said one to another Go to, let us make brick and burn them throughly. And they had brick for stone, and slime had they for mortar. And they said Go to, let us build us a city and a tower whose top may reach unto heaven; and let us make us a name, lest we be scattered abroad upon the face of the whole earth."¹

Early use of brick for structural purposes.

It is evident that the bricks spoken of here were not of the ordinary sun-dried variety common in the East, which were without doubt the first kind made and well known to these early builders, but kiln-burned brick of a superior quality. They were bricks "burned to a burning" employed in the erection of a building which was to be of great height and durability; and the emphasis placed upon the thoroughness of the burning shows that experience had already proven the value of long exposure to great heat in improving the quality of brick, both as regards its crushing strain and its power of resisting the elements. Indeed, from a careful reading of this passage, one might be almost inclined to claim that we have here the first mention of vitrified brick. We know also that at a later date the lives of the children of Israel in Egypt were made "bitter with hard bondage, in mortar and in brick," and that when their taskmasters withdrew the allowance of straw which they were accustomed to mingle with their clay, they were nevertheless required to furnish the same tale of bricks as before. It is probable that the Israelites were set to work upon the alluvial deposits of the Nile, whose sandy loams were wanting in tenacity and plasticity and required the admixture of some such material as chopped straw to enable the bricks to withstand the necessary handling before being dried. The treasure cities upon which the hapless Hebrews were engaged, Pithom and Raamses, have yielded their secrets to the archaeologist, and bricks containing chopped straw or stubble have been unearthed from the courses where in all probability they were laid by the compatriots of Moses and Aaron. These were most probably sun-dried brick, such as would soon crumble to pieces in our climate, but which under the rainless sky and eternal sunshine of Egypt have been preserved until now in as good condition as when laid. Hard-burned bricks have been found among the ruins of many of the buried cities of the East. At Khorsabad, a little modern village on the Tigris, on the site of the great palace built by King

Brick of Babel.

Brick of the treasure cities of Egypt.

Brick of buried cities of the East.

¹ Genesis xi: 1-4.

Sargon, a pavement has been uncovered of artificially burned bricks, so hard that when struck they rang like a bell ; as well as arched covers for sewers formed of radiating bricks accurately moulded, and glazed wall tiles in profusion.

PAVING BRICK IN MODERN TOWNS AND CITIES.

Introduction
of paving
brick in
America.

But though sun-dried and kiln-baked brick were among the earliest of architectural materials, the use of brick for paving purposes is of comparatively modern origin. Streets in some towns of continental Europe and England have been laid with brick for many years ; but it is in the United States and within the last ten years that the reign of paving brick may be said to have begun. To show the extent of the favor to which it has already attained, it has only to be said that in September 1893 there were in the United States no less than 139 manufacturing establishments in which street brick were made, and 311 towns and cities in which brick pavements were in use. Some of these manufactories are of great size, turning out as many as sixty millions of brick per year, and the industry is still rapidly expanding. Nor is the use of paving brick confined wholly to the smaller class of towns or cities. Among the large places which are giving it a trial are Boston, Detroit, Washington, Minneapolis, St. Paul, Buffalo, Rochester, Cincinnati, Cleveland, Kansas City, Atlanta, Louisville, Pittsburg, Philadelphia and Chicago. A recent list shows that in the State of Michigan eight cities have given in their adhesion to brick, in West Virginia nine, in New York sixteen, in Indiana seventeen, in Iowa twenty, in Pennsylvania thirty-nine, in Illinois forty-four, and in Ohio fifty-six.

Testimony in
favor of the
material

from Iowa.

The testimony given by these places is almost unanimous in favor of brick as a paving material. Judge E. H. Thayer of Clinton, Iowa, president of the Iowa Road Improvement Association and editor of the Clinton Daily Age, says in a letter to the Bureau, dated 22nd March, 1894 : " Vitrified brick for street paving is in general use in the West. For heavy traffic there can be no superior, and it answers the purpose fully as well as granite. In my opinion, it is the paving of the future of this entire country." Charles P. Chase, C.E., also of Clinton, and author of an excellent handbook entitled Brick Pavement, published in 1891, says under date of 6th April, 1894 : " If the best quality of brick is used and the work well done, I have no doubt but that it is the cheapest and most durable pavement for the money that can now be obtained. Our cities are disgusted with wooden pavements when compared with brick ; and granite and asphaltum are too expensive as a general thing. The best brick well laid will make a pavement as good as granite, except on streets where the heaviest traffic is carried on. It is easily laid or removed for repairs, is clean and sweet as compared with wood, and not as slippery as asphaltum or granite, and not as noisy as granite. . . . Our people here, and the same is true of other cities in this part of the United States, are pleased with the pavement, and the city is unable to furnish it as fast as the people call for it." In Chicago, if anywhere, the conditions of travel and traffic are sufficiently severe to put any kind of paving material to the test. In a letter dated 27th March, 1894, Mr. A. W. Cooke, Chief

from Illinois,

Engineer, Department of Public Works, Chicago, says : "Vitrified brick as a material for roadway paving has been extensively used in the United States for more than twenty years, principally in the cities and towns in the western central States, and whenever properly used has never failed to give satisfaction. . . . As compared with asphalt, granite and cedar block pavement, vitrified brick ranks second as to first cost ; first as to cost of maintenance ; first as to ease with which it can be repaired ; first as to durability under traffic ; third as to noiselessness ; second as to freedom from dust ; first as to freedom from decay ; second as to freedom from absorption ; first with granite as to foothold for horses ; and second as to ease of traction. In a sanitary point of view it is without a superior, and excepting asphalt, without an equal." In view of the great size of Chicago, the immensity of the traffic carried on there, and the wide experience which that city must necessarily have had with the various kinds of pavements, the certificate of Chief Engineer Cooke is high praise indeed. The city engineer of Memphis, ^{from} Tennessee, states that the pavements in that city are principally granite, limestone, gravel, macadam and vitrified brick. Of the last he says : "It has been in use in the city of Memphis under medium heavy traffic since April, 1889, during which time the city has not spent one dollar for repairs except where the pavement was torn up for repairs of gas and water pipes. I believe that the brick pavement is destined to supersede the various pavements heretofore used, and that it will be generally accepted in many cities except for very heavy traffic. It has given general satisfaction in Memphis as a sanitary pavement, being easily and economically cleaned. It is comparatively free from noise, and does not tax the nervous system like the stone and granite pavements. The surface is smooth, pleasing to the eye and affords a fair foot-hold for horses."² Many other similar expressions of opinion could be quoted. The sincerest testimony however which can be given is the rapidity with which the cities in all parts of the United States are adopting the new pavement. Mr. C. M. Rickard, City Engineer, Springfield, Ill., ^{and elsewhere.} says : "Street paving was begun in this city in 1883, and carried on to such an extent that in 1887 about twenty miles of streets were paved. The material used was hemlock boards and white cedar blocks, without tar. The life of this pavement laid on the hemlock boards was about seven years. . . . We have now begun repaving, and in the next few years all the old block pavement will have been replaced with brick. . . . During the year 1893 three miles of brick streets were paved at an average cost of \$1.26 per square yard. During the coming season there will probably be about four or five miles of streets repaved."³ There are sixty miles of it in Philadelphia and Germantown, eighty-five miles in Columbus, Ohio, ten miles in Indianapolis and five in Cincinnati, while New York, which has experimented with every variety of street material, is now paving Broadway south from Central Park with brick. The city engineer of Washington, says : "Owing to their more enduring qualities, we are paving all alleys with vitrified brick and repaving the gutters of streets paved with asphalt with them, as they have

² Paving and Municipal Engineering, February, 1894, p. 55. ³ *Ib.* p. 79.

better wearing qualities, and are not affected by water or uric acid from horses as is asphalt, and most of the new pavement is being laid with brick." The cities of the very first class, such as New York and Chicago, have been somewhat slow in making use of the new material, doubtless because of a suspicion that it might not withstand the impact of heavy loads and constant travel. Yet in the latter city the Chicago, Burlington and Quincy Railway Co. experimented with stone, asphalt and cedar blocks at its freight yards, and after discarding all for various reasons, put down brick, with the result that after a tonnage of 12,500 tons had passed over it daily for four years not a broken brick could be found. That company is so well satisfied with its experience in Chicago that it now uses it for paving all its yards where there is heavy traffic, its recent order for the St. Louis yards being a million and a half of brick.

A severe test
in Chicago.

Forecasting
brick pave-
ment works
for 1894 in
the U. S.

In the May (1894) number of *Paving and Municipal Engineering*, an excellent journal published at Indianapolis and devoted to subjects indicated by its name, a forecast is made of the extent and cost of public improvements to be made this year in fifty-four cities of the United States, based on returns received by the editor. Thirty-two cities report projected pavements as follows: Asphalt 288,163 sq. yds., brick 524,143 sq. yds. and macadam 383,086 sq. yds. The figures representing the cost are incomplete, but it is significant that the area proposed to be laid with brick is much larger than that to be covered with either asphalt or macadam, and is nearly equal to that of both combined. Louisville, Ky., appears in the list for 150,000 sq. yds. of brick at a cost of \$525,000, but the bulk of the outlay for brick streets is undertaken by cities of moderate size. Thus Burlington, Iowa, is down for 40,000 sq. yds., costing \$75,000; Decatur, Ill., for 33,000 sq. yds., costing \$50,000; Danville, Ill., 40,000 sq. yds., costing \$75,000; Huntington, W. Va., 20,000 sq. yds., costing \$25,000; and Titlin, Ohio, 25,000 sq. yds., costing \$68,000. On the other hand, Chicago proposes to lay 39,000 sq. yds. of asphalt at a cost of \$117,000, and 250,000 sq. yds. of macadam at a cost of \$225,000, while it is investing in only 6,000 sq. yds. of brick, costing \$12,000. Milwaukee is covering 100,000 sq. yds., and Indianapolis 95,066 sq. yds., with asphalt, while the latter city proposes besides to lay 40,700 sq. yds. of brick. It is evident therefore that while some cities of the first class are slow to commit themselves to brick pavements, brick is fast becoming, if it has not already become, the favorite material for towns and cities of less than the largest size.

Brick paving
in Ontario.

Chatham.

So far as is known, only two places in Ontario have made use of brick as a paving material. One of these is the town of Chatham, where in 1890 a brick pavement was laid down on King street, from the Rankin House almost to the Garner House, the busiest part of the main thoroughfare. The bricks were purchased from local brickmakers and were made from clay adjoining the town. They were not burnt hard enough for durability, but the pavement is in fairly good shape yet, and all are agreed that brick is the material for Chatham, provided suitable clay could be got and the brickmakers there had the proper appliances for burning it. The other place where vitrified bricks have been put down is Toronto, and to those

who have not watched local affairs closely it may be news that there are four Toronto miles of streets in this city paved with vitrified brick, all of which were laid down last year. The following are the streets: Dundas street from the bend to Lansdowne avenue; Lansdowne avenue from Dundas to College; College from Lansdowne avenue to Bathurst; Bathurst from Queen to Bloor. The pavement is between the street-car rails only. The bricks of which it is composed are all imported from the United States, partly from Massillon, Ohio, and partly from Canton, Ohio. The foundation is a bed of concrete, on which is laid a cushion of sand one inch in thickness, and on this the bricks are placed on edge at right angles to the kerb. They are laid as close to one another as possible, and the interstices are completely filled with paving pitch or Portland cement. Pitch is used on Bathurst street between College and Queen, and on College street between Bathurst and Dufferin, and cement on the remainder of the pavement. The cost of paving brick laid down in Toronto is from \$20 to \$23 per thousand, made up as follows: Price at place of manufacture per thousand, \$9 to \$10.50, freight \$9 and duty \$3. It takes from 60 to 64 bricks to lay a square yard of pavement, allowing for breakages. The brick pavements in Toronto having been down scarcely a year do not afford data for a conclusion as to their durability; we expect them to be yet practically uninjured and as good as when laid down. This on examination we find to be the case, and although, owing to the pavement being between the car rails only and thus by its position as well as by its smoothness offering a double inducement to vehicles of all kinds, it has received more than its fair share of travel, the only visible mark of wear is a slight rounding-off of the edges of the bricks. The comparative cost of the various kinds of pavement used in Toronto is as follows, including foundations:

Cedar block on 6-in. sand	\$.75 per sq. yard.
Cedar block, on 2 layers of 1-in. boards, with tar composition.	1.30
Cedar block, on 6-in. concrete	1.50
Light asphalt, 4-in. concrete, 2-in. asphalt	2.10
Vitrified brick, on 4-in. concrete	2.25
Heavy asphalt, 6-in. concrete, 2½-in. asphalt	2.60
Granite sets on 6-in. concrete	3.85
Scoria blocks on 6-in. concrete	4.00

The city authorities are very favorable to the use of brick as a paving material, considering it suitable for traffic of any kind, whether heavy or light. If good paving bricks were made here and sold for the same price as that charged by the United States manufacturers in their own markets, a saving of from 65 to 75 cents per square yard over present cost could be effected, which would reduce the cost of brick pavement to practically that of cedar blocks. In such a state of affairs there would be no choice whatever between the two kinds of pavement. The inodorous, bumpy, short-lived block would disappear forever before the clean, smooth, warm-colored and durable brick. There are miles of cedar block pavements in Toronto which are approaching the point when they must either be renewed or replaced by some better material. It would be a calamity if cedar blocks were again laid to furnish a repetition of the nuisance which this kind of pavement becomes in its unlovely old age; while on the other hand, a public benefit of no mean kind would be conferred by replacing them with smooth, lasting and sanitary brick roadways.

Comparison
with cedar
blocks as to
cost.

Cost of brick
pavements in
the U. S.

The cost of brick pavements in the United States varies considerably with the kind of foundation employed. It ranges from \$1 to \$2 per square yard, the average being perhaps about \$1.50. The cost of the bricks themselves for a single course pavement at a selling price of \$10 per thousand is about 65 cents per square yard. A few samples of the cost of brick pavements, together with the various kinds of foundation and methods of laying the brick adopted, may be quoted from Mr. Chase's manual, above referred to :

Bloomington,
Illinois.

In Bloomington, Ill., where some of the pavements are twenty years old and but little worn, the manner of laying is as follows : The foundation is brought to proper shape and well rolled ; then a course of cinders is spread on and compacted by rolling ; on this is placed two inches of sand ; then the first course of bricks on their flat sides with their long axes parallel to the street. Next comes an inch of screened sand, and then a layer of bricks edgewise on their two inch surface, and long axes at right angles to the street. The bricks are then covered with sand, which is swept into the cracks, and the whole pavement rolled with a heavy roller. There is no necessity of the sub course of brick being as hard as the upper course, but care must be taken to break joints in both courses. The entire pavement, including all materials, cost \$2 per square yard. A line of pavement running to the depot had, in 1891 been down for seven years, carrying all the freight to the railway and all coal from the coal shafts, a very heavy traffic, without showing any appreciable sign of wear.

Decatur, Ill.

In Decatur, Ill., the specifications required ; (1) foundation brought to desired crown 12 inches below grade and rolled with a heavy roller ; (2) a course of clean gravel, none larger than a robin's egg ; (3) one course of brick flat-wise, then one and a-half inches sand, and a course edgewise, and brick brought to a surface by striking with a maul on a plank ; (4) sweep in dry sand ; (5) brick extra hard and vitrified. The cost is \$1.50 per square yard. The oldest brick pavement at this place had been down six years in 1891, and then showed but little wear.

Stenbenville,
Ohio.

At Stenbenville, Ohio, hard burned bricks are used, chiefly obtained from New Cumberland, W. Va., and have given satisfactory results. They are laid on foundations of gravel similar to that used at Decatur. The wear is estimated at one-fourth to one-half an inch in five years. Cost of pavement, \$1 per square yard.

Peoria, Ill.

At Peoria, Ill., Franklin street, which in 1891 had been paved with brick three years and a half, is one of the principal thoroughfares and has a very heavy traffic. It was as pleasant to ride on as asphalt, and showed little or no signs of wear. The bricks used were larger than ordinary, being four inches thick, twelve inches long and five inches deep. They were laid on five inches of rolled gravel, the joints being filled with sand. Contract price, \$1.70 per square yard.

A record of
forty-two
cities.

In an admirable article on the Manufacture and Use of Paving Brick, read before the International Engineering Congress of the World's Columbian Exposition by Daniel W. Mead, that gentleman gives a table of forty-two cities in the United States where brick pavements are in use, showing the number of years the pavement has been down, the kind of foundation, the

average cost per square yard and other particulars. Cincinnati is shown to have laid a quantity of pavement four years ago on six inches of concrete at a cost of \$2.50 per square yard; a similar pavement in Indianapolis cost \$2.40 per square yard; one in Wheeling, W. Va., laid eleven years ago on eight inches of gravel, cost \$1.35 per square yard, while the premier pavement in Charleston, W. Va., placed in position twenty-three years ago on a foundation of three and a half inches of sand and tarred boards, cost only \$1.15 per square yard. In the cities of Illinois and Iowa, where paving brick is more largely used than in any other part of the United States, except perhaps Ohio, a variety of foundations is employed, comprising broken stone, cinders, sand, gravel, concrete, and usually a course of brick laid flatwise, which may be of inferior quality to those forming the actual surface of the street. A common foundation is six inches of broken stone, covered with two inches of sand, either with or without the overlying sub-course of brick laid flat. Six inches of concrete is also frequently used, and sometimes sand alone forms the bed on which the bricks are placed.

In the last-mentioned case the expense is low, as at Council Bluffs, where the pavement is stated to have cost only \$1.32 per square yard. A pavement resting on six inches of broken stone with a course of brick flat cost at Alton, Ill., \$2.16 per square yard; at Springfield, Ill., one on six inches of cinders cost \$1.50 per square yard; at Clinton, Ia., one on six inches of broken stone with sand, \$1.35 per square yard; and at Dubuque, Ia., six inches of concrete foundation brought the total cost of pavement up to \$1.69 per square yard.

FOUNDATION FOR A BRICK ROAD-BED.

A good foundation is as essential with vitrified brick as with any other kind of paving material. However excellent the surface covering of the street may be, it cannot but fail of achieving the best results if it does not rest on a proper substructure. The road-bed should be thoroughly drained, so as to secure the greatest possible freedom from moisture, that arch-enemy of pavements, equally objectionable in fluid or frozen form. When brought to proper sub grade, the whole surface of the roadway should be thoroughly consolidated by rolling or ramming. If the bed to overlie this is of gravel or broken stone, it should consist of pieces of uniform size, not too large, and free from dirt. If of concrete, the sand entering into the latter should be sharp, the cement of first-class quality, and there should be a due proportion of each in the mixture, say three parts of sand to one of cement; and the fragments of stone to complete the concrete should be angular, with rough faces, clean and not excessive in size. The concrete when deposited on the sub-grade should be rammed until loose mortar appears on the surface, and sufficient time should be allowed for it to set before placing the brick in position. On the concrete a layer of sharp, dry sand should be spread to the thickness of an inch or an inch and a half, to act as a cushion on which the bricks may rest. The bricks are placed on this on edge at right angles to the street, and in order that the joints may be broken, each alternate row should start at the kerb with half a brick. The bricks should be as close to

Importance
of a good
foundation.

one another as it is possible to lay them, and the interstices filled in with sand, paving pitch or cement. The last named is preferable for a lasting and substantial piece of work, as it is impervious to water and not loosened by the heat of the sun, which is not the case with sand and paving pitch, respectively. A drawback to the use of cement for this purpose is the length of time it takes to harden, while the pitch consolidates in a few minutes. It is difficult to exclude traffic from a street long enough to allow the cement to thoroughly and properly set.

Facility of making repairs or improvements with brick pavement.

It is frequently necessary to disturb the surface of the street in order to make repairs to sewer and gas pipes, water mains, etc., and the facility with which a pavement can be taken up and relaid is an important consideration. Brick is far ahead of asphalt in this particular, and is as easily taken up and relaid as either granite or wooden blocks. When the joints between the bricks are filled with sand, the bricks may be removed, cleaned and placed in position again with little or no trouble, but if pitch or cement be used, such repairs generally involve the destruction or rendering worthless of the bricks removed.

Suiting a foundation to the necessities of a street.

It is evident that for heavy and constant traffic, a foundation such as is described above is an absolute necessity, if a brick pavement is to have a fair opportunity of proving its smoothness and durability. For lighter traffic a less expensive foundation may suffice. The engineer of an Ohio town states that last year he put down a considerable area of brick pavement on a foundation of six inches of clean gravel, and one inch of sand. The usual drain pipes were omitted. The whole pavement, when completed, cost \$1.28 per square yard. Such construction might perhaps serve the purpose in small towns, but could scarcely be expected to stand the strain of heavy traffic. Mr. Mead says :

"For light traffic, the fragmentary materials, (rubble, gravel, sand, etc.), or sand with a layer of brick laid on their side, or six inches of concrete, make good foundations, the selection depending on the local resources. For medium traffic, nine inches of stone or gravel, or six inches of gravel or stone with a layer of brick laid on their sides, bedded in sand, or six inches of concrete, will give good results. For heavy traffic, the stone or gravel should be at least one foot in thickness, or the concrete at least nine inches."

Preferred size of brick.

Bricks of the standard size (which in Canada is $2\frac{1}{4} \times 8\frac{1}{4} \times 4\frac{1}{4}$ inches) are to be preferred. They are more likely to be thoroughly vitrified than larger blocks, which are frequently found unvitrified in the centre, and they possess an additional advantage from the manufacturer's point of view. In almost every kiln of brick burnt there is a percentage of the output too soft for paving purposes. These, if of the ordinary size, may be used in building, or for sewer arches, while if too large or of an odd size they would be hardly saleable.

BEST CLAYS FOR PAVING BRICK.

Tests of a good quality of clay for vitrifying.

All clay will not make good paving brick. Clay that will yield excellent building brick may be altogether lacking in the qualities necessary for good paving material. A brick that is made from coarse clay or one that has an excessive percentage of sand will be open and porous or easily broken, and

unfit for paving purposes. The best bricks are those made from a tough, plastic, smooth clay, with a fine grain, that will burn hard without warping, twisting or melting easily under a strong heat. It is impossible to determine either from the physical properties or the chemical analysis of a clay whether it will produce a satisfactory paving brick. The latter method of examination may indeed suffice to give a negative result; that is, if it reveals a large preponderance of undesirable, or an insufficient proportion of necessary elements, we may conclude that the clay in question is unsuitable for the purpose. But a sample of clay which passes muster under chemical analysis may fail when subjected to actual test. "The analysis of a clay is only presumptive The test of analysis. evidence of its adaptation to the various departments of clay working, and never to be taken as conclusive. The intense heat of the kiln may effect decompositions and develop combinations which are beyond the reach of chemical reagents. The presence of a great mass of highly heated material sometimes exerts an influence that cannot be produced in the laboratory."⁴

Mr. Edward Orton, jr., E.M., in a well written series of papers on the Clay-working Industries of Ohio, which have appeared in *The Clay Worker* (Indianapolis), agrees that the only conclusive test of the quality of a clay is actual trial. He says: "The heat test of clays, whether applied in special furnaces or kilns in a laboratory or carried on in the ordinary course of manufacture in the kilns of a clay plant, is the only important and convincing The test of trial. test which we can apply. By it each man learns what he needs to know, and only by it can the ultimate facts be known, for no matter what the source of our opinions or expectations may be, there is no assurance of the quality of a clay but actual trial. Even the predictions of a chemical analysis are secondarily useful, for while they are founded on the results of well known laws, there are still too many unknown and unexplained contingencies in the composition of clays to make a chemical prediction more than a reasonable probability. By an analysis certain things are indicated; we expect a fire trial will develop a result in accordance; it probably will, wholly or in part; but it is usually only in part, for such is the infinite variety of composition and combination in clays, that their products are somewhat like the human face, no two alike."⁵

Clay is the immediate or ultimate product of the decomposition of felspar, Constituents of clay. chiefly of the feldspathic ingredients of granitic rocks. The essential constituent is a hydrous silicate of alumina, known as kaolin, composed

⁴ Prof. R. T. Brown, formerly chemist of the United States Department of Agriculture, in *Brickmaker's Manual*, p. 167.

⁵ *The Clay-Worker*, April 1894, pp. 147-8. Mr. Orton's work in the line of clay-working and ceramics has recently been recognized. By enactment of the General Assembly of Ohio a Course of Practical and Scientific Instruction in the Art of Clayworking and Ceramics was added to the educational work of the University of that State. The department has already been organized with Mr. Orton as director, and the first term opens on September 12th, 1894. The course is intended to afford to young men engaged in brick works and potteries an opportunity to gain as much knowledge of the principal scientific studies touching their craft, with as little expenditure of time on other branches of science not so closely related to their work, as is possible. The course extends over two years, and the instruction covers physics, physical geography, chemistry, algebra, geometry, shopwork, clayworking, general and economic geology, mechanical drawing and drill. Particular attention will be given to chemistry, including the analysis of clays, limes, cements, felspars, pottery, glass, glazes, slips, enamels, etc. Tuition is practically free. This is the first instance in the history of this continent in which steps have been taken to put the ceramic industries on the plane occupied by those of mining, metallurgy and agriculture.

Residual and
sedimentary.

of silica 46.3 per cent., alumina 39.8 per cent., and water 13.9 per cent. This may be considered pure clay, which is rarely met with in nature. The clays of common occurrence contain a larger proportion of silica and a smaller proportion of alumina than kaolin, and variable quantities of numerous other ingredients, the chief of which are lime, magnesia, potash, soda and iron. The alkaline constituents of clay may be either the elements contained in the felspar of the original rock, or derived from extraneous sources; the iron is probably in most cases an added element, though originally present in some felspars as a coloring matter. Clays, considered with reference to the manner of their occurrence, may be either residual or sedimentary. Residual clays are the product of the disintegration of rocks in place, and where such a process has gone on free from the intrusion of other impurities, the leaching out of the alkalies may have left a bed of pure or nearly pure kaolin. Sedimentary clays are those which have resulted from the grinding up of rocks by glacial action, or the working over and transportation of residual beds. This class of clays is more likely to have retained the original composition of the rocks from which they were derived. Clays are found in all geological formations except the very oldest, and in many cases have, through the influence of heat and pressure, become indurated into compact rocks or shales. No one geological series has a monopoly of clay suitable for the manufacture of paving brick. The shales of various ages are now extensively used for the purpose, and even some drift clays, subjected though they have been to so many vicissitudes and exposed to contamination from so many sources, have been found to possess the requisite qualities.

Shales.

A wide range
of proportions
permissible.

An examination of the analysis of samples of clay used in making paving brick in various and widely separated portions of the United States shows that a considerable range is permissible in the proportions in which the main ingredients are present. It does not appear to be essential that the silica and alumina should bear any fixed relation to each other in quantity. In some samples the former is high, and the latter low, while in others the reverse is the case, with apparently little or no effect upon the quality of the product. Alumina shrinks, warps and cracks greatly in drying, but gives plasticity and adhesiveness to the clay and strength to the product. Silica prevents cracking and distorting, the more silica being present the less the shrinkage. But the greater the proportion of silica the less the plasticity and adhesiveness of the clay, and the weaker and more brittle the product. Neither does there appear to be any fixed standard for the fluxing constituents, either singly or taken together. What is doubtless true is that these should not fall below a minimum, otherwise the clay would refuse to vitrify; nor exceed a maximum, otherwise it would fuse too soon and melt out of shape at too low a heat.

On the subject of the physical and chemical qualities of vitrifying clay, Mr. Orton writes as follows in the series of articles above referred to:

What vitri-
fication means.

"In examining the subject it is found that clays used for making vitrified brick are chemically different from those used in making any other form of vitrified wares. Hence the following statements may be applied to all clays in which vitrification is an essential quality.

"Before taking up the consideration of the clays, it is proper to define somewhat more fully what is meant by the term vitrified.

"In the third paper of this series, the term was defined as indicating the incipient fusion and fritting of the particles of the clay ware into a new chemical compound, not necessarily glassy, but indicating by its fracture that such a chemical union has begun to take place.

"The degree to which such vitrification has taken place in a burnt clay is measured by its ability to absorb water, for as the chemical union progresses the pores of the clay become more and more constricted and the appetite for water less and less. If the clay be a good vitrifying variety, it will absolutely cease to absorb water at a temperature some distance beneath its melting point. Other clays, burnt at something near the same temperature, may enter into combination to a certain extent, but still absorb water freely. Such clays are perhaps somewhat vitrified after being burnt under such conditions; but under the classification proposed they must not be included as vitrifying clays.

"The physical peculiarities which mark vitrification in a burnt clay are the conchoidal fracture, absence of pores, and blending of the ingredients into one mass. Cracks, fissures and cavities may be found, but porosity must not exist in a well vitrified clay, and the original particles must have begun to cohere by the bond of heat instead of the bond of plasticity.

"It is impossible to convey adequately by words the peculiarities of fracture which indicate vitrification, but it is a quality which the natural sense of any observer readily teaches him to detect.

"Vitrification is thus seen to be a physical state or condition which any clay may assume if it is heated to the requisite point. The qualities which a clay must have to be profitably made into vitrified product are as follows: Qualities of a vitrifying clay.

"1. There must be a balance between the vitrifying temperature and the fusing temperature. Some clays begin to vitrify at low heat and become perfectly non-absorbent without ever approaching to a point where the clay becomes soft or bloated. Others stand heat well up to a certain limit and then fail rapidly. Obviously, the latter would not do for a vitrified product, for it would be impossible to burn a kiln of it without overburning a large quantity in order to obtain a sufficient heat to cause the rest of the kiln to properly vitrify. There must be a margin, or a tolerably broad range of temperatures, inside of which the vitrifying action takes place without approaching fusion; for if a burner is working between two extremes, too high absorption and porosity of his output on one side, and melted and twisted ware on the other, it is plain that he could not pay Peter without borrowing from Paul. Balance of vitrifying and fusing temperature.

"If a clay have this first great condition, it can be profitably worked, but its value will depend partly on two other factors, 2nd, plasticity; 3rd, color.

"2. The importance of the requisite plasticity is easily seen, for if it is not possessed it must be obtained by mixture which may interfere with the first and more important quality of vitrification. Again a balance of qualities is needed. Too great plasticity causes imperfect arrangement of the Plasticity.

particles of the clay in passing through the die of the machinery. Too little causes surface imperfection, cracks, toughness, etc. The majority of the vitrifying clays are not naturally very plastic as they occur; they may have been once, but the quality is gone, and it is only by fine crushing and very thorough tempering that plasticity sufficient can be induced. However, the faults of plasticity can largely be conquered by the use of proper mechanical means, while the vitrification depends on inherent chemical properties which we cannot vary or alter.

Color.

"3. The color of the ware is only important in view of a singular prejudice which the public have cultivated against light colored materials. The popular idea is that vitrification is measured by the dark color of the product, and that light colors are *prima facie* evidence of softness. This is by no means true. Many of the impure fireclay beds of the State make most excellent vitrified brick, but cannot be sold on account of their naturally light color. This difference is due more to the condition of the iron present than to its amount. In the light colored clays the iron is largely present as grains, while in most shales it is in the state which affects equally every particle of the clay, whether chemically combined or not."⁶

Sources of
vitrifying
clay.

Mr. Orton goes on to enumerate the sources from which vitrifying clay is obtained in Ohio. He states these as three: (1) The shale clays, coming largely from the coal measures, but represented in all of the older deposits as well; (2) the impure and low grade fire clays, coming from the coal measures; (3) river clays or sedimentary deposits of recent origin. The fire clays, together with the coal measures to which they belong, are absent in Ontario, although it is claimed that some beds of the Hudson River shales possess the qualities of fire clay. As to the sedimentary deposits of Ohio, they have so far found but limited use in producing vitrified wares, being too fusible, too plastic, and containing an undue proportion of limestone gravel, which spoils the surface of the ware after burning. Their counterparts in this Province supply the raw material for numerous building brick industries, but as yet no attempt whatever has been made to test their suitability for the manufacture of paving brick. Such efforts have been confined exclusively to the shales of our Hudson River and Medina formations, and it is encouraging to those engaged in these efforts to know that in Ohio the use of shale in the production of paving brick has given satisfactory results and is rapidly extending. It is stated by Mr. Orton that none of the three classes of clay enumerated above is in itself a perfect material for the purpose to which it is applied, though instances are found in which each is used alone with satisfactory results. The shales and river clays are too fusible and lose their shape at too low a heat, but vitrify perfectly. The fire clays are more refractory, owing to their high percentage of silica and comparative freedom from fluxing impurities, and they keep their shape well, but at the expense of vitrification. On this account a mixture of fire clay with either shale or river clay improves the quality of the product. As regards plasticity, the shales are as a class not sufficiently plastic to work alone; the river clays are too plastic, while the fire clays leave little to be desired in this respect. As to color, the shales

Advantages of
a mixture of
clays.

⁶ The Clay-Worker, May, 1894, pp. 544-5.

and river clays burn dark, the fire clays light. Both in point of plasticity and color, therefore, an admixture of fire clay with shale or river clay is found to be mutually advantageous. Mr. Orton gives an analysis of shale clays ^{Analyses of Ohio shales.} used in the manufacture of paving brick and sewer pipe at a number of establishments in Ohio, which is as follows :

Elements.	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.
Silica (total).....	57.15	58.30	57.10	49.30	57.45	55.60	58.20	58.88	57.28	57.40	56.61
Alumina	20.26	19.67	21.29	24.00	21.06	24.34	22.47	20.89	21.13	21.20	21.63
Water (combined)	5.50	5.15	6.00	9.40	5.90	6.75	6.15	7.53	5.22	7.75	.....
Clay and sandy impurities (total).....	82.91	83.12	84.39	82.70	84.41	86.69	86.82	86.80	83.86	86.35	.....
Oxide of iron	7.54	7.43	7.31	8.40	7.54	6.11	5.63	5.78	8.52	6.57	7.08
Lime .....	.95	.84	.29	.56	.29	.43	.62	.44	5.79	1.00	1.11
Magnesia	1.62	1.35	1.53	1.60	1.22	.77	.98	1.57	2.13	1.40	1.41
Potash	3.05	3.04	3.44	3.91	3.27	3.00	3.08	4.68	.....	4.10	3.51
Soda .....	.58	.73	.61	.19	.39	.69	.42	.34	.....	1.00	.48
Fluxing impurities (total)	13.69	13.39	13.18	14.63	12.71	10.40	10.73	12.81	16.44	14.07	.....
Moisture	2.70	2.65	1.30	1.20	1.90	2.65	1.65	.....	.....	.....	.....
Total	99.20	99.16	98.87	98.54	99.02	99.74	99.20	99.61	100.07	100.42	.....

1. Bucyrus Brick and Terra Cotta Co., Gloucester, shale.
2. Bucyrus Brick and Terra Cotta Co., shale and plastic clay mixed.
3. Royal Brick Co., Canton, O., Canton shale.
4. Waynesburg Brick and Clay Mfg. Co., Waynesburg, shales.
5. Ohio Paving Co., Columbus, O., Darlington shales.
6. A. O. Jones Co., Zanesville, O., shale and fire clay mixture.
7. T. B. Townsend & Co., Zanesville, O., shale and fire clay mixture.
8. Columbus Sewer Pipe Co., Columbus, O., Huron shales.
9. Akron Vitrified Press Brick Co., Independence, Bedford shales.
10. Akron Vitrified Press Brick Co., Independence, another sample.
11. Average of preceding ten analyses.

The average composition shows a clay containing 84.78 per cent. of clay base and silicious matter, and 13.22 per cent of fluxes.

HUDSON RIVER AND MEDINA SHALES.

A comparison of the chemical composition of the Hudson River and Medina shales of Ontario as given elsewhere in this article with that of the Ohio shales in the above table shows that the former contain a larger proportion of silica and a smaller proportion of alumina than the latter. The percentage of iron in both cases is nearly the same, while there is more lime and magnesia in the Ontario shales than in those of Ohio. As to the alkalies, potash and soda, the analyses of Ontario shales showing these constituents are too few in number to admit of a comparison being made. Judging from the chemical constitution only, the conclusion might be reached that on the whole ^{Comparison with the shale of Ontario.}

⁷ The Clay-Worker, May, 1891. p. 546.

the shales of Ontario, as represented by the samples of which analyses is given, are likely to prove less refractory than those of Ohio. The surplus of silica is counterbalanced by the deficiency in alumina, while the larger bulk of fluxing impurities would indicate the likelihood of greater fusibility. Whether this is an advantage or the reverse depends entirely upon the degree of ease with which fusion takes place in any given sample of clay. If there is sufficient refractoriness to permit of thorough vitrification before the point is reached when the ware breaks down and loses shape, the easy fusibility is a desirable quality, as less heat, and therefore less fuel, are required to complete the vitrifying process. If on the other hand fusion occurs and the product is run or twisted out of shape at a comparatively low temperature, it will be impossible to produce a properly vitrified article. Experiments so far point strongly to the conclusion that the Hudson River and Medina shales of Ontario are not too easily melted, but are sufficiently refractory to admit of proper vitrification, and this without requiring an excessive degree of heat. The samples of paving brick made from them, well vitrified and yet true in shape, testify that such is the case. These will be dealt with later on.

Analyses of
U. S. paving
clays.

In *The Mineral Industry* (1893) a table of analyses is given of paving brick clays from a number of localities in the United States, which is said to be very complete, and compiled from official sources. The table is interesting for purposes of comparison with the one just quoted. It will be noted that the average silica contents of the clays cited therein is considerably higher than that of the shales whose analyses are given by Mr. Ortón.

Locality.	Si O ₂	Al ₂ O ₃	Fe ₂ O ₃	Ca O	Mg O	Ti O ₂	Alk	H ₂ O
Bloomington, Ill	67.80	11.55	6.50	8.90	5.32	.....	2.42	0.20
Burlington, Ia	77.40	11.74	12.31	1.60	1.91	.....	4.23	.....
Clinton, Ia	73.82	15.88	9.16	trace	trace	.....	4.50	3.50
Franklin County, Kan	59.60	17.86	14.94	0.79	0.81	.....	.....	6.00
Leavenworth, Kan	58.43	21.96	8.43	1.05	1.47	.....	4.00	6.51
Flint Ridge, Kan	58.20	29.80	5.40	6.00	.....	.....	.....	0.60
Cheltenham, Mo	61.22	25.64	3.47	.....	.....	.....	1.31	9.68
Montgomery, Mo	43.93	40.09	1.70	.....	.....	.....	0.20	14.60
Kansas City, Mo	64.37	19.73	9.07	0.82	2.32	.....	3.78	.....
Cumberland, W. Va	69.02	22.07	4.53	1.70	0.38	.....	2.68	.....
Nuzum's Mills, W. Va	59.25	32.26	1.67	7.16	.....	.....	.....	6.30
Mount Savage, Md	39.90	30.08	0.88	.....	.....	.....	2.30	13.90
Robbins, Tenn	70.57	15.19	7.97	0.78	0.32	.....	2.30	.....
Hornellsville, N. Y	67.29	15.85	6.16	0.95	0.19	.....	8.71	.....
Warners, N. Y	52.30	18.85	6.55	3.36	4.49	.....	6.00	8.34
Woodbridge, N. J	42.23	39.53	0.50	0.01	.....	1.40	0.49	16.80
Phillipsburg, N.J.	56.78	17.38	0.50	4.14	3.15	.....	3.42	7.60
Columbus, Ohio	57.45	21.06	7.54	0.29	1.22	.....	3.66	7.80
Canton, Ohio	53.38	19.36	14.86	1.48	1.06	.....	.....	.....
East Palestine, Ohio	57.80	25.54	2.51	0.25	0.61	.....	2.69	10.60
Haydensville, Ohio	76.24	16.87	0.16	.....	0.50	.....	1.09	4.90
Woodlawn, Penn	42.15	31.43	2.32	0.32	2.01	1.00	.....	10.60
New Brighton, Penn	67.34	22.05	5.61	0.86	0.36	.....	5.40	.....
San Francisco, Cal	56.51	21.33	0.29	.....	3.53	.....	trace	6.30
Golden, Col	52.41	32.21	0.66	0.20	0.60	.....	0.61	14.05
Winchester, Ill	23.15	17.08	.....	.....	0.28	1.20	1.10	.....

These analyses exhibit surprising variations in the composition of materials used for a common purpose, not only so far as the silica and alumina are con-

cerned, but also in a smaller degree as regards the fluxing impurities. They are instructive as disclosing the fact that clays of the most unlike constitution are employed in the manufacture of paving brick.

EFFECTS OF FLUXING INGREDIENTS ON VITRIFICATION.

As regards the part played by the minor or fluxing ingredients of the clay in the process of vitrification, Mr. Mead says :

"Lime and magnesia, while infusible in themselves or with alumina, fuse in the presence of an excess of silica, as do also several other common ingredients of clay and form a vitrified brick." It is found that potash has the most active fluxing effect on clay, after which follow soda, lime, magnesia and iron, in the order named. To 'vitrify,' a clay should contain at least three per cent. potash, or three and one-half per cent. soda, or five per cent. of lime or magnesia, or eight per cent. iron, or a combined proportion of any or all of these fluxes equal to these amounts. An appreciably less amount of these fluxing elements will leave the product more of the nature of a fire-brick, unvitrified and porous, and, as a rule, unfit for paving purposes. A greater proportion than above specified is desirable and will make the clay more easily vitrified at a less heat, and is to some extent a measure of its economic manufacture, as a lower heat and consequently less fuel will be required in its burning. Too great an amount of these fluxes, amounting perhaps to three times the quantities above mentioned, will render the clay hard to handle on account of great fusibility. According to Richter, lime and magnesia are more active fluxing agents than potash and soda, but his conclusions do not agree with American experience. The presence of lime or magnesia in a paving brick in reasonable quantities is not believed by the writer to be detrimental to the brick if it exists in a finely divided state and is intimately commingled with the other constituents, so that a silicate of lime or magnesia will be formed in the burning. The Milwaukee building brick is one of the best of common brick, and it contains a large percentage of lime, and Portland cement contains often as high as sixty per cent. of lime. In each case however the lime exists in close chemical union with the other elements of the material. Iron in considerable quantities has a fluxing effect with silica, and to this extent cements it together and gives it strength. It is not the most valuable of constituents in this regard however, and its presence is not essential to a first-class paving brick. Iron, when present, is usually in the form of hydrous peroxide or protoxide of a yellowish or bluish color. During the burning, the water of crystallization is expelled and the iron takes the form of the red peroxide, giving its color to the material in proportion to the amount present. Potash and soda fuse at a lower temperature than the other constituents of clay, and their presence in suitable quantities is desirable for the manufacture of vitrified paving brick."

The fluxing ingredients of clays.

Mead's testimony.

Mr. Chase remarks on the same subject :

"Lime is very injurious to the paving brick, as it is changed to caustic lime in burning, and a small amount of moisture reaching this will cause it to slack and disintegrate the brick. A small amount of magnesia aids in producing vitrification. Iron is not injurious in a paving brick ; but in a brick to resist

Chase's testimony.

high temperature six per cent. of iron makes it useless. Alumina, and not iron, gives elasticity to the brick, is tough and binding, readily fusing in the presence of silica. The other constituents are impurities and act as a flux." ³

PHYSICAL PROPERTIES OF CLAY.

The physical properties of clay have an important bearing upon its fitness for use in the manufacture of paving brick. The hard, compact shales of the older formations, subjected as they have been in past ages to great heat and pressure, have to some extent lost that plasticity which is necessary to the proper handling and working of the raw material; hence such shales have to be reduced by mechanical means to a finely divided condition, and carefully tempered by the addition of water before they are in a condition to undergo the processes of manufacture. The fineness of the particles of which clay is composed likewise has considerable influence upon its behavior in the kiln. Coarse clays are difficult to vitrify even when the fluxing constituents are present in sufficient proportion, on account of their ability to withstand a large degree of heat. The more finely divided the clay, the more readily is it vitrified, and the tougher, stronger and more impervious to moisture is the product. The several ingredients of the clay may also vary in their action according to the condition in which they exist. On this point Mr. Mead says: "The uncombined silica may be more or less finely divided, and its condition has its effect on the action of the fluxes. In clays derived from felspathic or micaceous rocks, undecomposed feldspars and micas sometimes occur. Lime, instead of being finely divided, may occur as lumps or pebbles, in which condition it will unite with the other ingredients only on the surface, the balance burning into caustic lime, which on exposure will gather moisture and slack, disintegrating and crumbling the brick." It is even conceivable that two samples of clay, substantially identical in chemical composition so far as the proportions of the several constituents are concerned, may act quite differently in the kiln, owing to the different condition in which these constituents are present in the respective samples. A clay full of fragments of the original rock, for example, would be likely to require a considerably higher temperature for its vitrification than a clay resulting from the more complete degradation of the same rock; and this difference in temperature might bring about the production of two very unlike samples of brick.

One physical property, it may be remarked, is possessed by clays alone among the mineral substances found in nature, viz., plasticity. The cause of the plasticity of clays, by virtue of which they may be moulded into almost any desired form, does not seem to have yet been thoroughly explained, but it evidently depends largely upon the presence of the chemically combined water, as when this is driven off by heat the clay loses its plasticity, which can never be restored. Dr. Koenig of the University of Pennsylvania, who has made a study of this subject by means of microscopic investigations, states that kaolin or pure clay is composed of minute particles, loosely aggregated and invisible to the naked eye. Magnified 1,100 diameters, these

infinitesimal particles look like globules, and are not very unlike fish roe in appearance. In Dr. Koenig's opinion these particles are not crystalline; and he lays stress upon their similarity to globules of starch, as they are capable of absorbing water and of enlarging and passing into a plastic paste, the extreme mobility of which is accounted for by his assumption of the rounded form of the ultimate particles. Pure alumina is not plastic; neither is pure silica; yet when in chemical combination as a silicate of alumina there is developed this highly interesting property. If there be more silica present than can be taken up in chemical union by the alumina, the result is a lessening of plasticity, which goes on decreasing in proportion to the quantity of sand added. Clay loses its plasticity entirely at a low red heat, probably about $1,000^{\circ}\text{ F}^{\circ}$

MANUFACTURE OF PAVING BRICK.

The ordinary methods of making common brick require some modification in the manufacture of paving brick. If the raw material is shale, it is first reduced to a powder in a granulator or dry pan, and then thoroughly tempered in a pug mill before passing to the brick machine. The auger type of brick machine is the one more commonly employed, and the clay is handled in the condition known as "stiff mud." The "soft mud" process is not considered applicable to the manufacture of paving brick. Attempts are being made to adapt the "dry press" method, and on certain kinds of clay with a considerable degree of success. The drying of the brick previous to their burning is an important part of the process, and is best done on hot or slatted floors, or in flues or tunnels, by means of artificial heat. Outdoor drying cannot be depended on where the industry is conducted on a large scale. In the actual burning of the brick, the best results are obtained by means of the "down-draft" kiln. The fires are started slowly, in order to allow the water mechanically held in the clay to pass off as steam, which it does completely at a temperature of $212^{\circ}\text{ F}.$ This process is technically called "water-smoking." When the smoke issuing from the kiln shows no further signs of escaping steam, the heat is gradually increased, and at a little above $1,000^{\circ}\text{ F}.$, or a low red heat hardly perceptible in daylight, the combined water also

The stiff mud and dry press methods.

Burning.

In the appendix to *Brick and Tile Making* (London, Eng., 1868), Mr. Charles Tomlinson, F.R.S., speculates thus as to the cause of plasticity in clays: "We have seen that clay ceases to be plastic when its chemically combined water has been driven off. Still however water cannot be said to be the cause of plasticity as a general property, since we have in melted glass a more perfect example of plasticity even than in clay; and few substances are more plastic than sealing-wax at a certain temperature. A clear idea of plasticity and of some of the other mechanical properties of matter may probably be gained by considering them as variations of the forces of cohesion and adhesion, and by bringing these in their turn under Newton's great law of attraction, which, whether exerted between atoms or masses, is directly as the mass and inversely as the squares of the distance. . . . Now the method of arranging the particles of clay at that precise distance that shall impart plasticity is one of Nature's secrets that we have not yet succeeded in penetrating. It may be that the circumstances under which the clay is formed and deposited, or the time that has elapsed since its formation, or the pressure of the superposed layers, may have so arranged the particles as to enable them to become plastic when the proper proportion of water is added. It may be that a certain state of disintegration is required on the part of the alumina and the silica, so that their proximate elements shall be neither too fine nor too coarse; or it may be that the silica, in combining with the alumina, separates the atoms of the latter to precisely those distances required for the development of the property: or, lastly, the presence of a small portion of animal or other organic matter in clay may have something to do with this remarkable property."

passes off. Any organic matter present is now eliminated, and sulphur compounds broken up, part of the sulphur going off in the smoke. This is a critical stage of the operation. As the combined water is expelled the particles of the clay begin to settle together and the pores to close up; and if the heat be too quickly raised this process goes on so rapidly at the outside of the bricks that the gases evolving in the centre find it difficult or impossible to force their way out. In this case the imprisoned gases will distend or "bloat" the bricks and perhaps ruin their shape altogether. This is more apt to occur in the burning of large paving blocks, or bricks of extra size. The chemical changes are accompanied by corresponding alterations in the physical conditions of the clay. The expulsion of the water has brought about a shrinkage in the size of the bricks, which are now denser, harder, and stronger than before. Their weight is subject to no further reduction. If the contents of the kiln have safely passed through this ordeal, there is usually little

Vitrification.

further need for fear in the burning. The heat is again raised, and vitrification shortly begins to set in, whereby the various constituents of the clay are chemically combined into one compound silicate. This process may be regarded as the initial stage of fusion, but must not be carried to the actual point of fusion, otherwise the clay will melt and run entirely out of shape. As the heat becomes nearly as great as the clay can bear, the structure of the latter is so changed that instead of exhibiting a rough, stony fracture, the clay will break with sharp edges like glass, and will no longer absorb water.¹⁶ After vitrification occurs, the kiln must be gradually cooled down previous to the removal of the brick. From two to four days are required for "water-smoking," from four to six for burning proper, and from three to five for cooling. If cooled too rapidly, the bricks become glassy and brittle, while by

Cooling down.

allowing the heat to slowly subside they are toughened, and as it were annealed. Indeed the term "annealed brick" has been proposed as a substitute for "vitrified brick," as being more descriptive of the essential quality of a first-class article. The word "vitrified" conveys the idea of a glassy, and consequently a brittle product, while the fact is that good paving bricks, though "vitrified" in the sense of being rendered impervious to moisture, or nearly so, are tough and very difficult to break. As a matter of fact, it is possible to produce a paving brick of fair quality without vitrification. Where the raw material approaches a fine clay in its composition, it may be difficult or incapable of fusion, and yet may yield a paving brick suitable for a warm climate and for moderately heavy traffic. Bricks made in certain parts of West Virginia from clays of this kind have given good satisfaction. A degree of vitrification is however requisite for a rigorous climate like our own, as a brick which would absorb any appreciable quantity of moisture would soon be shattered by the keen frosts of our winters.

¹⁶ The degree of heat required to bring about these changes Mr. Orton found to vary between 1,800° F. for shales and 1,920° F. for fire-clay, the product being paving bricks. The temperature of open hearth steel in the furnace before being tapped for pouring was 2,660° F.; of mill iron as it ran from furnace to casting bed 2,225° F.; inside of boiler firebox 2,175° F.; of another firebox 2,295° F. The Clay-Worker, April, 1894, p. 447.

 QUALITIES OF PAVING BRICK.

A first class paving brick will resist a file or emery wheel almost as effectually as a piece of cast iron. It should have a specific gravity of about 2.25, and be capable of sustaining a crushing strain of about 12,000 lb. per square inch. Bricks of fair quality will vary in specific gravity from 2.03 to 2.41, and in crushing strain from 9,000 to 13,000 lb. per square inch. The crushing strain of granite varies from 5,000 to 21,000 lb. per square inch. The test for crushing strain however is difficult to apply, and unless made under definite conditions is uncertain in result. The transverse strength of a brick, viz. the weight it is capable of sustaining in the centre while the ends are resting on supports, is more easily ascertained, and representing as it does both the compressive and tensile strength of the material, probably indicates more nearly the value of the brick for actual wear in the street. A standard brick should exhibit a transverse strength of at least 1,600 lb. to the square inch.

The percentage of water absorbed by a paving brick is an important test of its quality. The best bricks will not take in more than 2 per cent. of their own weight after an immersion of three days, while a common red building brick which has a specific gravity of 1.82 per cent. will absorb as much as 15.13 per cent. of its own weight in the same time. The ratio of absorption, however, is usually greater than 2 per cent., and in some cases runs as high as 3 and even 5 per cent., though brick of this latter quality should be looked upon with suspicion, and as scarcely suitable for use in northern climates. The presence of caustic lime in a brick is also revealed by the immersion test. Caustic lime has a great affinity for moisture, and if it be present it will absorb the water and break or crack the brick, or will form "poppers" on the surface.

It is customary to test paving brick for its resistance to abrasion by placing the specimens in a foundry tumbler with pieces of cast iron, and after submitting them to so many hours' friction at a given number of revolutions per minute, to calculate the loss as compared with the original weight. No standard of comparison has yet been fixed for this test, but it is useful in determining the resisting powers of bricks of different makes, or of bricks delivered on a contract as compared with the samples.

 THE CLAYS OF ONTARIO.

No general or systematic examination has yet been made of the clay or shale deposits of Ontario with a view of determining their value for manufacturing purposes. There is abundance of clay adapted for the production of building brick in almost every part of southern and western Ontario. In very many places pockets of clay on the surface of the drift are utilized for this purpose, some burning red and some white. These local deposits are usually of limited extent and of variable character, and are unlikely to prove sources of supply of paving brick. The Erie and Saugeen clays are widely distributed throughout the Province, and are generally capable of being burnt into building brick.

The Erie clay, which when moist is of a blue color with thin gray bands, burns white and is largely used for brickmaking where it does not contain too great a proportion of lime. In the northwestern portion of its area, as in the counties of Bruce and Huron, it is frequently too calcareous to admit of successful use in brickmaking. The thickness of the Erie clay is thought not to exceed 200 feet. The Saugeen clay, which overlies the Erie, and is sometimes separated from it by beds of sand, is thinly bedded and of a yellowish or brownish color, contains considerable lime, and is extensively used in the manufacture of bricks, which are usually red in color. The thickness of the Saugeen clay is probably somewhat less than that of the Erie. The classification of the stratified clays of Ontario into the Erie and Saugeen beds was first made by Sir William Logan, and while doubtless it is sufficiently accurate in the main, there are localities where deposits of clay are found which do not accommodate themselves to this division. One example is in the exposure made at the works of Messrs. Taylor Bros. on the Don, near Toronto, where overlying a deposit of brown sand which covers the till, there is a bed of dark brown clay twelve feet thick burning red. Above this, but separated from it by several other beds, and immediately below the surface, is a bed of brown clay sixty feet thick burning buff. If we have here the Erie and Saugeen clays respectively, they give precisely the opposite colors on burning to those assigned them by Logan. So far as known, no experiments have been made with the Erie and Saugeen clays in the manufacture of vitrified brick, but probably they would be found to contain too large a proportion of lime for successful use. The boulder clay or till of course cannot be availed of in the manufacture of bricks of any kind on account of the great number of pebbles and boulders which characterize it.

The Palæozoic shales.

The Palæozoic formations of Ontario, which end in an unimportant and restricted section of the Chemung and Portage group of the Devonian series, do not afford so great a variety of shales and clays as a complete section of the geologic scale would do, and are notably deficient in the fire clay deposits so characteristic of the carboniferous measures. Shales and argillaceous rocks however form part of nearly every one of

Hudson River the formations subsequent to the Archæan. In the Hudson River and Medina formations we have inexhaustible supplies of material from which not only building brick, pressed brick and sewer pipe may be made, but also paving brick of excellent quality. The Hudson River shales are exposed in a number of places in the neighborhood of Toronto, in particular by the Don and Humber rivers and at Mimico. At the works of Messrs Taylor Bros. on the west bank of the Don the shale, which immediately underlies the till, rises ten feet above the level of the valley, and has a depth as ascertained by borings half a mile distant of about 400 feet. Above the shale is the boulder clay in a bed three feet thick, which is followed by a deposit of coarse sand colored brown by iron stain, about eighteen feet in thickness; this is succeeded by a bed of clay twelve feet thick, dark brown in color, which burns red, and overlying this is ten inches of light brown clay exceedingly fine in grain, which burns white. Next in ascending order is a grayish

in the Don valley.

Taylor Bros. works.

clay six feet in thickness which burns gray, or green when exposed to intense heat, and above it is a similar thickness of reddish clay turning red. Over this and extending to within a few inches of the surface is a thick deposit, probably sixty feet in perpendicular depth, of a brown thinly-bedded clay, which burns buff. From a mixture of the several clays with one another and with the shale bricks of a variety of pleasing colors are produced. A quarry has been opened on the shale to furnish material for the manufacture of pressed brick, and is now perhaps eighty feet in depth. It shows the shale to be interbedded with thin bands of limestone which have to be culled out. This firm, with characteristic energy, have added paving brick to the other branches of their industry, already including pressed brick of a great many kinds and colors, plain and ornamental, terra cotta, and enamelled brick. An exhibit of Don Valley pressed brick took the highest award at the World's Columbian Exposition. A large kiln has been erected on the continuous principle, and it is the intention to undertake operations on a considerable scale in the manufacture of paving brick from the shale. Of course the shale requires to be ground before being worked, and as it is found that the greater the depth the harder the shale, it is customary to dig a supply and expose it to the disintegrating influences of the weather for a time. Following is an analysis of the Hudson River shale of which the Don Valley pressed bricks are made, furnished by the kindness of Dr. Coleman of the School of Practical Science :

Hygroscopic water.....	1.50	per cent.
Water (combined) and CO ₂	5.51	"
SiO ₂	60.55	"
Al ₂ O ₃	14.79	"
Fe O ₂	7.58	"
Ca O.....	1.81	"
Mg O.....	1.55	"

The Rosedale Pressed Brick and Terra Cotta Company, whose works are situated at the base of the high bank overlooking the river and a little farther down stream than the Taylors', have apparently a large supply of promising clay, and are also proposing to enter into manufacture of paving brick. Rosedale
Pressed Brick
and Terra
Cotta Co.

The Toronto Vitriified Paving Brick and Stone Company have a very conveniently situated property on the east bank of the Humber, at the point where Bloor street strikes the river opposite the old stone mill. The Hudson River shale outcrops in the bank of the river and rises there perhaps 20 feet above the water. As the property extends over a number of acres there is a plentiful supply of the raw material. The shale is here interbedded with bands of calciferous sandstone of varying thickness, which would have to be laid aside in the working.¹¹ Shipments of brick could be made either by means of scows (the river affording a depth of 12 feet of water) or by rail, a switch of the Belt Line railway running into the property. A large building has been erected, some of the machinery put in place and two kilns par- In the "Hum-
ber valley."

Toronto
Vitriified Pav-
ing Brick and
Stone Co.

¹¹ A little higher up the river, on Mr. Baby's farm, there is a lofty bluff in which bands of shale and sandstone are exposed, and where quarrying operations could be carried on very economically. The river at this point has furnished an excellent building stone for many years, and every freshet brings new supplies to the surface. North of the bluff a sand road makes the ascent of Tee-nail Hill to the old Indian burial ground, so well known to local antiquarians.

Analyses.

tially completed, out of a plant intended eventually to produce 50,000,000 bricks a year, but the recent financial depression has obliged the company to cease operations, and at present progress is suspended. Analyses by Dr. Coleman and Prof. Heys of the shale give the following results, which seem to show that it is not the same in quality throughout :

I. (Dr. Coleman).

Hygroscopic water	1.24	per cent.
Water (combined) and CO ₂	6.07	"
Si O ₂	63.47	"
Al ₂ O ₃	11.28	"
Fe O	6.90	"
Ca O	3.30	"
Mg O	2.20	"
K ₂ O	3.41	"
Na ₂ O	2.60	"
	100.47	"

II. (Prof. Heys.)

Silica	55.28	per cent.
Alumina	24.29	"
Oxide of Iron	6.82	"
Lime	1.68	"
Magnesia .....	.80	"
Carbonic acid	1.31	"
Sulphuric acid	1.25	"
Moisture and organic matter	6.57	"
Alkalies and loss	2.00	"
	100.00	"

At Mimico.

Mimico Sewer
Pipe and
Brick Manu-
facturing Co.

At the Mimico Sewer Pipe and Brick Manufacturing Company's works, Mimico, the Hudson River shales come to within a few feet of the surface. Immediately below the soil is a deposit of yellow clay about three feet thick, of suitable quality for mixing with the shale in the manufacture of sewer pipe, and below this is a bed of gray calcareous clay of the thickness of a foot. Immediately underlying the latter is the shale, which here as elsewhere is interbedded with bands of limestone. This company is engaged chiefly in the production of sewer pipe, but has also been experimenting with its material with the view of making vitrified brick. Some excellent samples have been produced. An analysis of the shale by Dr. Coleman shows it to have the following composition :

analysis.

Hygroscopic water	1.34	per cent.
Water (combined) and CO ₂	6.08	"
Si O ₂	58.18	"
Al ₂ O ₃	15.47	"
Fe O	7.42	"
Ca O	2.61	"
Mg O	2.98	"

Medina.

Hamilton and
Toronto
Sewer Pipe
Co.

The red Medina shales, which have seldom a less thickness than 500 feet, are already utilized on a considerable scale by various firms in the manufacture of pressed brick, terra-cotta and tile, at Milton, Beamsville, Terra Cotta and elsewhere. At Hamilton they furnish the Hamilton and Toronto Sewer Pipe Company with the raw material for excellent sewer pipes and building brick, and the company are now proposing to add to their extensive business the manufacture of vitrified brick. Their works consist of two distinct plants, one of which is not at present in use, but is likely to be made the scene of the new industry. A mixture of 50 per cent. shale and 50 per cent. clay is used for the sewer pipe, and a like mixture will probably be employed for the paving brick. The clay is simply disintegrated shale and is found immediately at the base of the mountain, where the shale in place outcrops

under the Medina sandstone, as well as overlying the greater part of the level ground between the mountain and the bay. A quantity of the raw material was sent to Canton, Ohio, and manufactured into paving bricks there. An analysis of the mixed clay and shale ground ready for use, made by Dr. Coleman, is as follows :

Water (combined) and CO_2	4.17	per cent.
SiO_2	61.79	"
Al_2O_3	14.53	"
Fe_2O_3	8.35	"
CaO	0.85	"
MgO	2.28	"

The clay being wet, was dried at 100°C . before weighing ; and as it was red in color the iron was determined as Fe_2O_3 .

To his building-brick manufactory on the outskirts of Toronto Junction, Mr. C. R. S. Dinnick is adding a plant for making vitrified brick. The raw material which Mr. Dinnick proposes to use is a mixture of the red Medina shale and clay, and after considerable time and money spent in experimenting he believes he has discovered the proper proportions in which such a mixture will give the best results. The samples he has produced from his own kilns appear to be of good quality.

TESTS OF ONTARIO PAVING BRICKS.

Vitrified bricks from some of the shales and clays of Ontario mentioned above were recently subjected to a test at the School of Practical Science, Toronto, by Mr. C. H. C. Wright, B.A.Sc., lecturer in Architecture, the object being to determine (1) their powers of absorbing moisture, and (2) their transverse strength. The bricks so tested were made from the Hudson River shale at the Don and Mimico, and the Medina shale and clay at Hamilton. Along with these were submitted for purposes of comparison several bricks of well-known manufacture in the United States. The results were highly gratifying, especially at the present experimental stage of the industry here, when it is not to be expected that the best methods have been found or the greatest skill in manipulation acquired. The test was indeed surprisingly favorable to the Ontario bricks, goes far to show not only that we have here the right material on which to base the manufacture, but also that Ontario makers may hope with time and experience to produce an article which will withstand competition from any quarter. In ascertaining the powers of absorption of the various samples, or rather their capacity to resist the penetration of water, the bricks were placed in a drying chamber and subjected to heat until they ceased to lose weight, thus depriving them of all their hygrometric moisture. They were then immersed in water, and weighed at intervals of three, five and fourteen days, with the results as noted in the respective columns of the table given below. It will be observed that much the larger proportion of water taken up was in every instance during the first period of three days, and that there was comparatively little increase in weight after the fifth day. In the absorption test the Syracuse brick, which proved itself almost impervious to water, took first place, the Ontario samples ranking second, third and fourth, and showing a marked superiority over two of the American bricks. The possession of high non-absorptive properties in a brick is good evidence of thorough vitrification, and is a prime requisite in a climate like our own. In

more southern regions, where the temperature is uniformly higher, this quality probably has not the same importance, but the effect of our keen frosts on a pavement of water-soaked brick would be very disastrous.

The transverse strength of the bricks was preferred as a test to their crushing strain, which is the one usually taken, for two reasons, (1) it is more likely to be a true index of the quality of the brick, and (2) it more nearly represents the conditions of actual wear. In the usual method of ascertaining the crushing strain a one or two-inch cube is cut from a corner of the sample and subjected to the test. In hammering, chipping and otherwise dressing this small cube to the perfectly exact dimensions required, there is considerable risk of weakening it by starting flaws or cracks, not discernible to the eye, yet of sufficient importance to vitiate the result of the test. This objection does not apply to the test for transverse strength, which is made on a machine constructed for the purpose by placing the specimen on rests near the ends and then applying pressure in the centre until it gives way. The weight registered by the machine at the instant of yielding is the total pressure applied, from which the pressure sustained per square inch is easily calculated. A pavement is very rarely called upon to withstand anything like a pressure of 10 000 or 12,000 lb. per square inch, which is about the crushing strain capacity of good paving brick, and in any case it is evident that the wear due to dead weight pressure is very small as compared with that caused by impact and friction. The transverse strength test, on the other hand, indicates the power of a brick to resist pressure and at the same time to withstand the flattening-out or stretching tendency induced by a superincumbent weight. In this test the Syracuse brick again headed the list, the Ontario samples standing second, fourth and sixth. The average transverse strength shown by these seven samples was 2,659 lb. per square inch, while the average of the three Ontario bricks was 2,681 lb. per square inch. Good quality paving brick is expected to stand a transverse strain of not less than 1 600 lb. per square inch, so that every one of the samples tested was more than equal to the requirement in this respect.

The bricks experimented upon were from the following Ontario manufacturers, viz.: Hamilton and Toronto Sewer Pipe Company, Hamilton; Tylor Bros., Toronto, and Mimico Sewer Pipe and Brick Manufacturing Company, Mimico; and from four well-known firms in the United States, in Galesburgh, Ill., Syracuse, N.Y., Canton, Ohio, and Cumberland, W. Va.

The following table shows the result of the test for absorption:

Brick No.	Weight in pounds.				Total increase. lb.	Percentage of increase.
	Dry.	3 days in water.	5 days in water.	14 days in water.		
1	6.908	7 000	7 027	7 047	.139	2.01
2	7 344	7 375	7 375	7 375	.031	.42
3	6 078	6 094	6 098	6 109	.031	.51
4	5.984	6.078	6 194	6 109	.125	2.08
5	4 625	4 625	4 627	4 627	.002	.04
6	7 090	8 068	8.738	8 750	1 750	25.00
7	6.891	7.862	7.987	7.901	1.010	14.65

Table of absorption test.

In the test for transverse strength the bricks were placed on edge, or with the narrow side up; and the usual formula for determining the modulus of rupture was applied, viz.: $f = \frac{3wl}{bh^2}$, where w = centre load in lb., $l = \frac{1}{2}$ span in inches, b = breadth, and h = height. The following table gives the results, and also the size of the bricks in inches :

Brick No.	Transverse strength lb. per sq. inch.	Size of Bricks (inches).		
1	1,793	2.525	x	4.050 x 8.500
2	2,549	2.600	x	3.900 x 8.750
3	3,703	2.375	x	3.875 x 7.750
4	3,134	2.325	x	3.800 x 8.125
5	3,972	2.000	x	3.650 x 7.500
6	1,948	2.560	x	3.700 x 8.500
7	1,515	2.500	x	4.250 x 8.500

THE CLAY WEALTH OF ONTARIO.

The enormous value which lies latent in our vast deposits of clay is as yet but faintly realized. A beginning has been made in their utilization by establishing the manufacture of pressed brick. This industry is hardly more than six years old in Ontario, and already it has proved a source not only of private gain, but of public benefit on a large scale. Employment has been furnished to the workingmen of our Province, for the processes through which the clay must be put before reaching the stage of the final product require the assistance of many hands, and to this extent the necessity of leaving our country to seek work elsewhere has been lessened. One more avenue has been found for the employment of capital at home, and it is no less important to check the exodus of capital than that of labor. Capital is the stream, labor the wheel which it turns; "useless each without the other." We cannot continue to send our surplus capital to be employed in enterprises outside of the country without at the same time sending thither our laborers to assist in the application of it. Capital and labor flow along the line of least resistance, and both will find their way to the place where they can secure the greatest return. But a current of either capital or labor once established in a particular direction is difficult to divert except by the certain prospect of profitable employment nearer the starting place. The pressed brick industry of Ontario has given an instance of how such a diversion may be effected. Large manufacturing have been built, large sums of money expended in establishing them, large amounts have been paid, and, notwithstanding the present depression, are still being annually paid as wages to workmen, and to railways for transportation. These are the results to private individuals directly interested in the business. But the public as well has been benefited. Building material of superior quality has been furnished those who wished to erect houses, and the use of pressed brick and terra cotta in our cities and towns has added very largely to the beauty and durability of recent architecture. The old roughly-made, soft-burned and easily disintegrated bricks have given place to well-formed, hard burned, dense articles, far superior in lasting qualities, at a cost not actually much greater and indeed much less in proportion to their value.

Employment of labor and capital at home.

Paving brick industry.

There is a still larger field standing open for the manufacture of paving brick, and even greater benefits will be conferred upon the public by its introduction than in the case of pressed building brick. Vitrified brick is fast assuming the first position on the list of paving materials in the United States, and it is coming more and more into use as its merits become known. We in Ontario cannot long remain behind our neighbors; and indeed the chief if not the only obstacle in the way of its adoption here is the excessive cost induced by the expense of bringing the material from the other side. If the attempts being made to produce a first-class article from our own clays prove successful, this difficulty will to a large extent disappear, for the cost of manufacturing here ought to be little if at all above the cost of manufacturing in the United States, and vitrified brick of Ontario manufacture should sell as cheaply, or nearly so, as that of Ohio or Illinois does in those States. The market is that of the towns and cities of the Province, of neighboring Provinces, and perhaps—if production can be sufficiently cheapened—of neighboring States also. There is no danger of an exhaustion of the market, for so long as man maintains his gregarious habits, so long will there be cities and towns with streets to be paved and re-paved; and as taste improves and higher standards are set up people will demand the best, particularly if the best can be supplied at a moderate cost. The first manufacturers will have the field to themselves, for there is a substantial impost on the imported article, and even without it the freight on a thousand of Ohio paving brick is almost equal to the prime cost, and quite sufficient to give the home manufacturer an indisputable advantage in the markets of his own Province.

The benefits
of well paved
streets.

The immense benefits which well paved streets would confer on the inhabitants of our towns and cities can hardly be estimated. Every working horse, every buggy, delivery wagon or dray would have a longer life; larger loads could be taken and consequently the cost of hauling and delivery would be lessened; no longer would rainy weather and the wheels of traffic churn the surface of streets into eye and nose-offending mud; time would be saved by the increased rapidity with which distances could be traversed; frequent and expensive repairs would be obviated; and the public health would be improved, for the streets could be readily and cheaply cleaned and no excuse would exist for allowing disease-breeding filth to find lodgment under the public gaze. The establishment in our Province of a paving brick industry is calculated to bring about such a state of affairs. It would afford employment for labor and capital. It would be another step in the utilization of our dormant resources, and a distinct advance in national progress and development.

T. W. G.

VI.

ROCKS AND BUILDING STONE.

By Dr. A. P. Coleman, Toronto.

Geologists and architects have at least one interest in common, they both deal in what a geologist calls "rocks" and an architect "stone." The rocks of the geologist include however the sand of a seashore, the soil of a field and the ice of a glacier, whereas no architect would think of building in any of these materials unless perhaps an ice palace at Quebec, Montreal or Ottawa, this or some other winter. The geologist, when dealing with rocks, is apt to dub himself a petrographer or lithologist, but the architect is more modest and gives himself no special name because he builds in stone.

The petrographer divides rocks into three grand divisions,—massive or igneous rocks, resulting from the cooling of melted material; schistose rocks, having their minerals arranged in a parallel way so as to split most readily in one direction; and sedimentary or clastic rocks, made of fragments of other rocks deposited by water. The massive rocks show the greatest variety of minerals, and are always taken up first. Their mineral constituents are of two kinds,—essential, when their absence would throw the rock into another species, and accessory, when less important.

The mineral playing the largest part in the formation of rocks is quartz, rock crystal when it displays its own form, a six-sided prism ending in a pyramid. It is the hardest of the essential rock forming minerals, is almost unattacked by the weather, and therefore is the most useful constituent of many stones suitable for building. Next in importance come the feldspars, orthoclase with its flesh red or white cleavage surfaces, and plagioclase showing delicate striations on cleavage planes. The former is a silicate of alumina and potash, and the latter of alumina and soda or lime. Some of the plagioclase feldspars have a magnificent play of color, as in labradorite. Of the darker rock minerals, mica, hornblende and augite are most important. There are several kinds of mica, but we need mention only muscovite, a silicate of potash having pale colors, and biotite, a magnesian silicate very dark in color. All micas may be recognized by their very perfect cleavage into exceedingly thin elastic plates. Hornblende is a dark colored silicate having two planes of cleavage with an angle of 124° between them. The scales cleit off are not elastic. Augite or pyroxene, another dark, almost black silicate, has usually no distinct cleavage, and may be distinguished thus from hornblende. Of the accessory minerals, few are of much interest to us, though garnet, often of a fine red color, occurs in many archæan rocks in Ontario, and tourmaline in black triangular prisms may sometimes be seen. The most important of the accessory minerals to the architect is iron pyrites, a hard, brassy looking sulphide

of iron crystallizing in cubes, which under the action of the weather may change to a sulphate and finally stain the rock where it occurs rusty brown with oxide of iron.

Massive rocks.

Granite, syenite, diorite, and gabbro.

Turning now to the rocks themselves, granite is naturally taken up first by both petrographers and architects, as the most widespread and useful of the group. It consists essentially of quartz, felspar and mica or hornblende, and takes on gray or flesh red colors from the prevalent orthoclase felspar. It is one of the handsomest and most durable of building stones, and but for its great hardness would no doubt come into much wider use. Its one defect is the ease with which it crumbles under the action of intense heat, as shown at the Boston fire. If quartz be omitted from granite, the rock is called syenite, which has the same colors and uses as the previous rock, though a little softer to work. When the felspar is striated and mixed with hornblende, forming a dark green or black rock, it is named diorite; if augite is the dark mineral the rock is diabase or gabbro. All these rocks fall into the same line in the hands of the builder, who sometimes calls them black granite.

Porphyry.

Porphyries are rocks unlike those that have been described in that the general mass is fine grained or compact in structure, enclosing larger grains or crystals of quartz or the felspars. Some of the porphyries are very handsome stones for ornamental work, but are little used in building.

The more important ancient massive rocks have now been described, and it will scarcely be necessary to take up in detail the corresponding series of modern eruptive rocks, including the lavas, such as trachyte and basalt.

Schistose rocks.

Gneiss.

The schistose rocks too need only a brief mention, since only one of them, gneiss, practically granite, having a parallel arrangement of its mica plates, is used to any extent for building. In Norway one sometimes sees a whole house built of gneiss, roof as well as walls.

The sedimentary rocks.

Far more important are the fragmental or sedimentary rocks, which provide the most commonly used building stones. We may divide them into three groups, those made of clay in some form, those made up of silica or the silicates (quartz, felspar, etc.), and those which consist of carbonate of lime, or of this with carbonate of magnesia.

Slates.

The clayey or argillaceous rocks are usually too feeble and easily acted on by the weather to be of use in building. The slates however, which are clays consolidated and metamorphosed, are an exception, since innumerable minute crystals of mica and other minerals have begun to form in them, binding the materials together and giving a resistance to the weather surpassed by no other rock. The perfect cleavage which gives slate its value as roofing material does not correspond to the stratification, as one would expect, but has been caused probably by strong lateral pressure in mountain building. The different tones of color in slates are taken advantage of by architects to give variety in roof effects.

Sandstones.

Perhaps the most useful group of rocks in architecture is that of the sandstones. Breccias, made up of large angular fragments, are too rare to find much place as a building material; and conglomerates, formed of rounded pebbles cemented together, are also rarely put to use, though some notable buildings, such as the Pitti palace, are built of them. Our brilliant jasper

conglomerate from Lake Huron with its red pebbles on a white ground might give striking effects, though it would be very hard to work. It would probably last for eternity however, if put into a building. Sandstones, on the other hand, are among the most favored building materials. They consist chiefly of grains of quartz, often with a large admixture of fragments of felspar or other silicates, and result from the destruction of the older massive rocks. The cement binding the particles together has a great effect on the durability of the stone, and should receive more attention than it does from architects. A siliceous cement forms a rock difficult to work, but lasting practically forever. A ferruginous cement consisting of oxides or carbonate of iron is a durable one, and occurs in many reddish or brownish sandstones. The cement is said to be calcareous when carbonate of lime is deposited between the sand grains. Such sandstones effervesce with cold dilute acid, and the lime is more or less easily attacked by rain charged with carbonic acid from the air of cities, allowing the stone to crumble. The least efficient cement of all is argillaceous or clayey, and sandstones containing it readily disintegrate when exposed to the weather in a climate like ours. The clayey odor when breathed upon affords a rough test for the argillaceous cement. It is an unhappy fact that the durability of a sandstone is often in inverse ratio to the ease with which it is worked, so that the builder is tempted to use the poorer qualities.

Last come the carbonates, consisting of calcium carbonate in limestone, and of calcium and magnesium carbonates in dolomite. The two may be distinguished by the action of cold acid, which effervesces strongly with the carbonate of lime, but hardly at all with dolomite. The limestones are generally formed of broken shells, though in many compact varieties, such as lithographic stone, the fossils have completely disappeared. Porous modern limestones, formed by springs, are called travertine. The most ancient limestones have been so metamorphosed as to become thoroughly crystalline, and when very fine grained and pure white are statuary marbles. Many of the colored varieties of so called marbles are really however encrystalline limestones. The limestones are often admirable building stones, durable and handsome, but are apt to be attacked by the atmosphere of great cities charged with acid fumes. The dolomites resist this action somewhat better. A very handsome variety of chemically deposited carbonate of lime, sometimes used for interior decoration, is called Mexican onyx in the trade, though incorrectly, since the true onyx is a variety of silica.

Carbonates.

Limestone and dolomite.

The coloring matter of rocks is usually some compound of iron. Reds are caused by the sesquioxide, hematite; browns and yellows by the hydrous or brown oxide. Red and brown sandstones are good examples of this; the paler they are the less oxide of iron they contain, while pure white ones are practically free from this metal. The flesh color of orthoclase felspar in the granites arises also from the red oxide of iron. On the other hand, silicates and other compounds of iron in the monoxide state show various shades of green or gray, or almost black, as in the diorites and other greenstones, in green slates, and greenish gray sandstones. These green monoxide compounds of

Coloring matter of rocks.

Weathering
quality of
rocks.

iron tend to weather into the ruddier sesquioxides. One often notices that pale greenish sandstones turn yellowish or brownish on exposure, a result of slow oxidation of ferrous oxide. The darker limestones are usually colored with bituminous or coaly matter, which on exposure gradually oxidizes; so that a blue limestone eventually bleaches to a pale gray, almost white.

The weathering quality of rocks is a matter of great interest to architects, for on this turns the permanence of their work. Certain rocks, such as quartzites and sandstones with a siliceous cement, are practically indestructible by the weather, as one can see on surfaces scoured by glaciers during the ice age seven thousand years ago, but still showing the polish and scratches then given them. Rocks formed of silicates, like granite and syenite, are also very resistant; others, like the limestones and marbles, are slowly dissolved by rain and are more rapidly acted on by the impure air of large cities, which contains traces of sulphuric acid. The dolomite of the English Parliament buildings is said to be suffering badly from this cause. Sandstones with clayey cements are readily disintegrated in moist and changeable climates; and stone containing much iron pyrites should be looked on with suspicion, since it is very apt to weather into brown oxide of iron, weakening the stone and giving rusty stains. The porosity of a stone is a matter of prime importance in a climate like ours, where water-soaked walls may be quickly crumbled under the action of frost.

Effects of cold
and heat on
rocks.

In rocks composed of several different minerals, like granite, great changes of temperature tend towards disintegration through unequal expansion. Quartz has a cubic expansion of .000036 for one degree centigrade; orthoclase, only seventeen parts in a million. In case of a great fire, where the temperature may be raised suddenly 1,000° or more, this unequal expansion sets up strains which split off the surface, as in the great fires of Boston and Portland, where massive granite buildings crumbled to ruins. One would expect limestones to burn to quicklime and thus fall to pieces, but actually they resist far more heat than granite, while sandstones resist fire best of all.

The testing of
rocks.

The last point to be referred to is the best means of testing a rock intended for building purposes. The test of time is of course the most convincing of all, but then one cannot always wait a thousand years to see how durable a building stone is. The resistance of a cube of stone to crushing strain gives useful evidence as to its strength, and the amount of water it absorbs helps to a decision as to its durability in frosty climates; but the most valuable test of a scientific kind is a petrographical examination. By the microscopic study of thin rock sections one can determine the actual minerals that make up a rock, their relationship to one another, their state of freshness or decay, and the character of the cement that binds the particles together. No other method will give such complete evidence as to the internal structure of a rock, on which its durability depends, as a careful examination of sections under the microscope.

VII.

LITHOGRAPHIC STONE.

In the Report of the Bureau for 1892 an account was given of the opening and working of a quarry of lithographic stone by Dr. Volney of New York, near Crow lake, in the county of Hastings. This quarry is on the farm of Thomas McGraw, and consists of fifty acres, being part of lot 9 in the third concession of Marmora, on the south side of Crow lake. A small mill has been erected near the quarry for dressing the stone, and samples sent to New York are said to have proved very satisfactory. Dr. Volney hopes to organize a company to undertake operations upon a larger scale.

Half a mile west of the Volney quarry a new property was opened last year, and a mill was built to dress the stone for market. This locality was prospected in 1892, and in December of that year or in January of 1893 a joint stock company known as the North American Stone and Asbestos Company was organized to carry on operations. The capital is \$200,000; George Clawson of New York city is president, and A. M. Olsholm of the same place, formerly of Marmora, is general manager. Samples of stone taken in 1892 having been tested in New York, the Company proceeded to acquire the mineral rights on an area of 313 acres, consisting of 165 acres owned by William Bonter, parts of lots 6 and 7 in the third concession, 135 acres owned by Edward Bonter, parts of lots 7 and 8 in the third concession, 8 acres owned by Thomas McGraw, part of 8 in the third, and 5 acres owned by Patrick McFaul in the second concession. The consideration paid was \$4,800.

In April of last year work was commenced by opening a quarry on lot 7 in the third concession, close to the south shore of Crow lake, and about the same time the erection of a mill was undertaken. The ground where the quarry was opened is ten feet above the level of the lake, and the rock is covered with only a few inches of drift. The formation is Trenton limestone, very evenly bedded, but showing a slight dip to the southeast—about two inches in 100 feet. A hundred yards from the lake the ground begins to rise, forming an old shore line. The quarry is 100 feet long by 50 wide, and has been opened to a depth of 25 feet. The jointings are in straight lines, and far enough apart for blocks to be taken out of any size that is likely to be required. The first layer of lithograph stone is 7 feet from the surface, and has a thickness of 10 inches. It is marked with a white cloud, and is not of uniform texture. Three inches below it is the second layer, 7 inches in thickness. The third layer has a thickness of 16 inches, the fourth 12 inches, the fifth 15 inches, and the sixth, seventh, eighth and ninth from 6 to 8 inches. All these layers are separated from each other by beds of limestone ranging from 3 to 14 inches in thickness, and suitable for building stone. The several

The mill.

layers below the first differ from each other more or less in color and texture, one being of a dark cream color, and the others of varying darker shades from gray to blue. The fifth is a dark blue stone, but very fine in texture. Owing to the nearness of the quarry to the lake, there was a constant flow of water into it between the beds after the lake level was reached; but with a pulsometer pump no difficulty was experienced in keeping the water under control.

The mill is a frame structure, 35 by 88 feet, with an engine and boiler room attached, 20 by 24 feet. The boiler is 120 h.p., and the engine 95 h.p., built by Hamilton of Peterborough. Two gangs of saws have been set up in the main building, the saws being of common band iron. Sand is fed to them automatically, and water is supplied from an overhead tank. The planer is of Brooklyn manufacture, and has a bed area of 36 by 52 inches. The cut of the saws is at the rate of $1\frac{1}{2}$ inch per hour, and as they are run night and day when the mill is in operation, their capacity is 3 feet per day. The mill was started about the first of June, and operations were continued to the 10th of November. During this time twenty men were employed at the works, fifteen in the quarry and five in the mill and blacksmith's shop.

Tests were made in New York with 45 stones from the several layers, and all except those from the top one were pronounced "O. K. and all right." These stones were from 20 by 30 inches up to 36 by 52 inches; but stones have been taken out 6 feet square without a flaw. The demand is for the larger sizes.

It is the intention of the Company to add to the sawing and planing capacity of the mill and possibly also to manufacture vitrified brick. The top layer of the lithographic stone appears to be well adapted for the latter purpose with the addition of other materials, as shown by samples made in New York.

Kelly's property.

Another location of lithographic stone is lot 9 in the fourth concession of Marmora, the property of Mr. William Kelly of Marmora village, who purchased it from Hon. Malcolm Cameron in 1870. A Detroit syndicate procured an option on this lot last year, and at the time of my visit to Marmora in the latter part of November prospecting operations were being carried on upon it under the direction of Mr. Wayne Choate, a mining engineer from Detroit. The top layer of lithographic stone has a thickness of 10 inches; six inches below it is a second layer of 30 inches, and a foot below the second is a third of 18 inches. The middle one is lightest in color and the best in quality. The same bands of lithographic stone are seen to outcrop on the banks of Crow river, at the village of Marmora, but the stone there is marred with fine crystals of calcite.

Old quarry on Crow river.

In 1862 or 1863 an American company built a mill to manufacture lithographic stone at a point lower down the river, on lot 6 in the fourth concession; but the quality was not suitable. The property was afterwards bought by the late Judge Sherwood, and by him sold to Mr. Kelly. The area of this location is only one acre.

VIII.

MOSS-LITTER.

By Edward Jack, Fredrieton, N.B.

The application of moss as bedding for horses and cattle is of ancient date, especially in Sweden, where the inhabitants who resided near the moors have made use of it for a long time in a small way. But it was only in the year 1880 that moss litter was made an article of manufacture and commerce, and this was done by Hollman, at Gifhorn in Hanover. Torf mull (turf dust) had also previously to this time been made use of in Sweden, on a small scale, as a deodorizer in closets. In what the Germans denominate high moors, water mosses take the most important part, especially the sphagnum, of which we have very many varieties in Canada. This is usually the predominant plant so long as the moor continues growing; where this growth from whatever cause ceases, either on the whole or in places, heath plants, such as *Cassandra*, *Andromeda*, *Kalmia* and *Ledum* spring up.

The introduction of moss litter as an article of manufacture and commerce.

That property which renders turf most suitable for the purposes of litter is its absorptive power, which varies much in different kinds. While some kinds of turf in an air-dried condition, containing 20 per cent. of water, will absorb but twice their own weight of fluid, there are others which take it up even to twenty times their own weight. This difference is owing to the structure of the turf, and in part depends upon its botanical constitution, as well as on its degree of decay. The more the turf is decayed the less quantity of fluid is it able to absorb. The bright, light, fibrous, but little decayed turf, which forms the upper layers of many moors, has a much greater absorptive power than the dark heavy turf, which is much better however for use as fuel.

Absorptive property of turf.

But the botanical composition of the turf is of more importance than the degree of decay. The moors which are formed by the growth and decay of the various sphagnum mosses occupy the first place as a source of supply for moss-litter. The remarkable absorptive power of these mosses depends upon the peculiar structure of their cells, which is found in but few others. The leaves and epidermis of the stalk are very largely composed of large empty cells, which can fill themselves with water by means of a number of holes. The cell walls are prevented from collapsing through the ring or spiral-formed thickenings with which their inner sides are provided. They are thus always distended, and thus always ready for use. Between these cells lie smaller ones, which contain chlorophyl and afford nourishment to the plant. They take up however but a small space. This capillary apparatus enables the sphagnum plant to raise the water to its highest parts, even when these are above the water level. By the felting of the moss there is also formed, so to say, a net of water-absorbing channels which act in the like manner.

The sphagnum mosses.

Experiments
at Jonkoping.

The absorptive power of the turf is also dependent on the fineness of its division. Von Feilitzen made some experiments on the subject at the experimental station at Jonkoping in Sweden, the results of which were as follows :

1. The turf broken up by hand into large pieces took up 16.36 times its own weight of water.
2. After the turf had been passed through a sieve with one and a half millimetre mesh it took up 18.83 times its own weight of water.
3. Using a sieve of a mesh of one-half a millimetre, only 14.08 times its own weight of water was absorbed.

A simple test
for ascertain-
ing absorptive
power.

Since the value of turf used as a moss litter depends in so great a degree upon its absorptive power, which again is dependent on its dryness, it is very necessary that one should have some simple way of ascertaining this, for moss-litter containing 30 per cent. of water seems to the touch to be dry. In order to make this test, all one has to do is to weigh a sample and allow it to remain for three days in water. It is then placed on a sieve which had been previously weighed, and the superfluous water allowed to drain off in a cold room where there is but little evaporation taking place. The difference in weight, deducting that of the litter in its original state, will give the absorptive power and consequent value of the article. The writer found by such a trial that the absorptive power of the sphagnum moss taken from the great moor at Shippegan, in the county of Gloucester, New Brunswick, was seventeen times the weight of the original moss, which had been previously dried artificially. The absorptive power which can be profitably made use of must be below that number, for the very act of removing this specimen from the sieve caused a large loss in the water which it had absorbed.

Absorption of
gases.

The sphagnum moss has not only great absorptive power in so far as water is concerned, but also as respects gases. Its absorption of ammonia is in part due to the free humic acid which may be found in connection with the litter ; but according to experiments carried on at the Experimental Moor Station by Dr A. Koenig the ammonia was arrested chiefly by the pores of the plant. An experiment made by the regimental veterinary surgeon Arnold at Hanover on the purity of air in the stables where moss-litter was used for bedding, shows this absorptive power for gases well. The moss-litter used was strewed to the thickness of twelve centimeters, the air was examined daily, and its contents of ammonia ascertained. The result for six days showed the gas contents in a given quantity of air each day to be as follows :

Experiments
at Hanover
with moss and
straw.

Day.	Where moss-litter was used.	Where straw was used.
	Gram.	Gram.
1	0.	0.0012
2	0.	0.0028
3	0.	0.0045
4	0.	0.0081
5	Trace.	0.0153
6	0.0010.	0.0168

While the much decomposed dark turf can remain long in the water without taking up very much of it, the brighter air-dried fibrous moss is a mos

ready absorbent, and can take up just as much water as it was originally able to do. There is also a great difference in the absorptive powers of the various layers of the same moor. Experiments made at the Experimental Moor Station gave as the result of the absorptive power of the different strata of a north-west German moor at Osterholz the following numbers :

Depth of layer experimented on in centimetres.		100 parts of dried moor substance absorbed water in parts—
0—27	Much decomposed heath humus, passing over into much decomposed moss turf.	890
27—43	Moss turf, with some remains of eriophorum, (a common bogplant in northern Canada; the spike in fruit looks like a tuft of cotton.)	1,390
43—61	Clean undecomposed moss turf.	1,560
61—76	In part, much decomposed heath earth; in part, little decomposed moss turf.	820
76—91	Mixture of heath earth, moss turf, and remains of eriophorum	720
91—104	Chiefly much decomposed heath turf, with a little undecomposed moss turf and remains of eriophorum.	570
104—117	The same.	590
117—131	Nearly amorphous heath turf, with a small quantity of undecomposed stalks of heather.	510
131—151	The same.	400
151—157	The same.	400

It is a matter of prime importance that means should be taken to drain, so far as possible, any moor which is intended to be made use of as a source of supply of moss-litter. In some of the North German moors a simple and easy way of securing the material has been for some time in use. At the commencement of the winter the surface of the moor is ploughed to a moderate depth, and then allowed to remain over winter in order that the frost may act upon it, since the frozen turf dries quicker than that which has not been exposed to the frost; and experiments have also proved that the moss which froze when full of water loses by thawing alone a considerable quantity of it. In the following spring these furrows are gone over with a harrow, and in dry weather they are repeatedly harrowed with a lighter harrow. So soon as the first layer appears to be sufficiently dry it is removed; the harrowing, drying and removal are again repeated, so that this may be done in Germany as many as ten times during a very dry summer. In other cases the turf is dug or cut in pieces, or clods. These are then piled in conical heaps, a vacant place being left in the centre so that the sun and wind can have their full action on them. While the pure sphagnum affords much the best litter, it must be remembered that the remains of various other plants found in bogs are also used for such purpose. A specimen of German moss litter, such as is now being used at the rate of 50 tons per week in Boston, was sent the writer a few weeks ago; no sphagnum plants were visible in it, and it was altogether inferior to moss-litter which can be furnished from Canada.

The preparation of moss-litter is very simple. The first operation is the breaking up of the sods, which is done in a machine called a Reisswolf, which is nothing more than a cylinder, inside of which there is a revolving roller, provided with bent iron teeth. By this means the clods are reduced to the proper size, and come out at the bottom of the cylinder. With this a shaking sieve is connected, which separates the moss-litter from the dust, or torf mull, an article which is now being made use of in Germany and elsewhere for many important purposes. The Reisswolf may be driven by hand, horse or

steam power, according to the amount of work required to be done. The material thus reduced in size and separated from the mull or dust is introduced into a press somewhat similar to the American beater, where it is pressed into bales of about 1.25 metres long by 0.75 metres broad. Before its removal from the press it is protected at the angles by laths, and the whole firmly held together by four pieces of iron wire, two of these near the centre of the bale, while the other two are fastened around it near either end. From 50 to 60 of such bales constitute a load in Germany for a common railway car.

In stalls of all kinds, as in the case of straw, the litter must be kept and applied dry. For a beast which is constantly in the stall a hundred weight of moss-litter per year should be allowed for each hundred of live weight of the animal; working beasts require less. The litter should be strewn to the depth of 12 to 15 centimetres; this may be allowed to remain untouched for a fortnight. If one would be saving, such part of the litter as becomes damp can be raked up under the crib to dry there, in order to be used again, but it is better to remove the wet litter and replace it by dry. About 75 kilograms are required monthly per horse; cattle, on account of their more watery excrements, require more. By the use of moss litter the animals are provided with a suitable, soft, elastic and dry bed, they are kept clean, while the air in the stables is rendered pure, and lung diseases prevented. The most valuable part of the animals' secretions, which is nearly all lost by the use of straw, is completely saved for the agriculturist by means of the absorptive powers of moss-litter, and it has also been experimentally established by one of the leading veterinary surgeons of Berlin that in stables which were well provided with moss litter there was 30 per cent. fewer cases of hoof lameness than in those which were not furnished with that material.

Mode of using
the litter in
the stalls.

Value of moss-
litter as a
fertilizer.

Some experiments were made in Germany in the year 1883 in order to ascertain the difference between the value of moss-litter and straw as fertilizers after they had been used in the stall. With this object in view nine head of cattle were allowed to stand six days in a stall, where they were bedded with rye straw to a depth of from twelve to thirteen centimetres; during the next six days moss-litter was used for bedding. The analyses gave the following results in 1,000 parts of dry dung:

	With straw litter.	With moss- litter.
Potash.....	16.23	16.99
Lime.....	8.85	9.11
Phosphoric acid.....	7.91	8.33
Total nitrogen.....	15.12	19.63
Easily soluble nitrogen.....	0.31	2.14
Difficultly soluble nitrogen.....	14.81	17.49

In the autumn of 1884 further experiments were made in Germany on ten milch cows bedded in a similar manner, with the following results in 1,000 parts of dry dung:

	With straw.	With moss- litter.
Potash.....	16.3	15.4
Lime.....	5.4	5.0
Phosphoric acid.....	12.1	12.7
Total nitrogen.....	24.9	29.4
Easily soluble nitrogen.....	7.8	12.6
Difficultly soluble nitrogen.....	17.1	16.8

The remarkable increase in the amount of easily soluble nitrogen is a very noticeable feature in the above analyses. This easily soluble nitrogen which had been fixed by the moss-litter was lost in the case of the straw, which allowed it to escape in the ammonia, and circulating through the air of the stable rendered it unhealthy for the cattle which were compelled to live in it. From this experiment on these ten cows it was shown that by using moss-litter instead of straw for bedding about 140 kilograms of easily soluble nitrogen was in this case saved in the course of year.

In small towns where there are no proper systems of sewerage or drainage the air is often poisoned by the escape of gases from cesspools and places of deposit for feces; by the use of moss litter and turf dust this could be avoided and those disagreeable odors could be transformed into a most valuable fertilizer to add to, instead of taking from, the comforts of man. The accumulation of fecal matter in cities or towns has been and is the chief cause of epidemics and infectious diseases, and one may well conceive what a blessing it would be were this waste matter rendered not only innocuous, but even brought to the farmer and market-gardener as a most useful accessory to his other fertilizers. Notwithstanding all the care which can be taken in protecting the contents of cesspools by means of stone and lime, various experiments have shown that the soil under and around them is more or less permeated by fecal matters, and thus a nursery is formed for bacteria and other noxious micro-organisms. Moss-litter, which possesses so strong an absorptive power for gases as well as fluids, when rightly applied can be made to remedy the evil; for not only will it prevent the escape of noxious fluids and gases, but it will also check the growth of injurious micro-organisms. In order to apply the moss-litter in such cases, it must be broken up into small pieces before being thrown into the cesspool. It has been estimated that two hundred weight of good moss-litter will absorb 1,000 litres of fluid, and that the use of a hundred weight of moss-litter for the absorption of the feces of each person per year will be enough on the average. It is most advisable to begin the strewing of the litter after the pot has been emptied, and regular application should be carefully attended to so soon as any bad odors are perceived. After some time the contents of the pot are absorbed and can be shovelled out, being as free from smell as common earth. Experiments carried on for seven months in Germany, on the content in carbonic acid of the air in the neighbourhood of a cesspool which had been treated with moss-litter showed that by the use of this article the carbonic acid had decreased from 3.097 per cent., the original content prior to the use of the litter, to 1.074 per cent.

Uses of moss
litter in towns.

Use of moss
litter for cess-
pools.

In various German cities the use of moss-litter has been introduced, partly in an obligatory and partly in an optional manner. Were the fecal matter of our smaller towns thus preserved for the use of the agriculturist and market-gardener, the saving which would be effected can easily be shown to be enormous. That this can be done with a profit to the towns themselves has been proved by various instances in Germany.

According to Professor Heiden an animal weighing 1,000 pounds live weight will produce yearly sixty-four hundred-weight of liquid dejections, the

Value of
liquid manure.

value of which he estimates at thirty-five marks. More than two-thirds of this he says is lost under ordinary management, but by the proper use of moss-litter this can to a very great extent be prevented ; but as the property of moss-litter to fix ammonia is not without bounds, the addition of a little kainite to it will check the escape of any surplus nitrogen, as will also that of wood ashes or ground plaster.

Preservative powers as packing material.

The preservative powers of moss-litter are due to its property of absorbing gases and moisture, thereby among other things checking the growth of bacteria. Instances are given by the German authorities where sea fish by its use have been transported fresh for a long distance and were received in good condition at their destination more than a fortnight after they were caught. Autumn pears packed in it are reported by the same authorities to have been as good early the next summer as when they fell from the trees. Potatoes also when packed in it all winter were perfectly fresh during the succeeding summer, showing neither rot nor any signs of germination.

Experiments in Canada desirable.

The writer knows of no experiments having been carried on in Canada to test these preservative powers of peat moss, but it would seem very desirable that such should be made. In case this were attempted the cleanest and brightest sphagnum litter should be selected, and in order to increase its efficacy it should be artificially dried so as to expel as much as possible of the water which the common air-dried moss contains. Some of these deposits of Canadian sphagnum are remarkably free from any impurities. The upper layer of the great Shippegan moor, which consists nearly altogether of the remains of plants of *sphagnum fuscum*, is so clean that the water squeezed out of the dead wet moss taken from a distance below the surface is not only perfectly transparent but also tasteless. The habitants when crossing this moor often dig a hole and quench their thirst with the clean cool water which flows into it.

Prospects of a market.

There can be no doubt that peat moss can be raised and dried as well in Canada as in Germany ; that we have it in as great quantities and of as good quality here as there ; and that were this industry once started we would not only be able to supply all the wants of our own towns, but also have a large surplus for exportation. Four or five years ago Rothbart estimated the annual production of this article in Germany at 1,300,000 hundred-weight, part of which was used there, the balance being exported to England, America, and even to the East Indies.

In the preparation of this short article on moss-litter, the writer acknowledges his indebtedness to the German authorities, especially to Furst, Fleischer and Junger.

IX.

IRON TRADE OF THE UNITED STATES.

For the week ending February 3, 1894, there were 130 furnaces in blast in the United States, producing 101,043 tons of pig iron. In the corresponding week of 1893 there were 248 furnaces in blast, producing 174,534 tons. The total production in 1894 to February 3 was 505,215 tons, and to the corresponding date in 1893, 872,670 tons. This shows a decrease of 367,455 tons in a little over one month, or about 42 per cent. The Engineering and Mining Journal says: "That the iron and steel trade has been and is still demoralized to an extent that was never before known since iron was first made in this country, is a stubborn fact well known to those engaged in the business. . . . Prices for all descriptions of iron and steel, raw and finished material, are away below any prices that were ever dreamed of, and there is apparently no room for further reductions in rates without going below the cost of manufacture."

Condition of
the pig iron
trade in the
United States.

A bulletin of the American Iron and Steel Association shows the production of pig iron in the United States in 1893 to be 7,124,502 gross tons, being 2,032,498 tons less than in 1892. The following table gives production by half years for the last four years:

Pig iron pro-
duction.

—	1890.	1891.	1892.	1893.
	tons.	tons.	tons.	tons.
1st half	4,560,513	3,368,107	4,769,683	4,562,918
2nd half	4,642,190	4,911,763	4,387,317	2,561,584
Totals	9,202,703	8,279,870	9,157,000	7,124,502

As compared with the first half of 1893 the production in the second half of that year shows a decrease of nearly 44 per cent., the largest semi-annual decrease in production of which there is any statistical record.

The total production of Bessemer steel ingots in the United States in 1893 was 3,123,524 gross tons, against 4,168,435 gross tons in 1892, showing a decrease of 1,044,911 tons, or over 25 per cent. In the last half of 1893 the production was only 1,031,467 tons against 2,092,057 tons in the first half—a falling off of more than 50 per cent.* The production of steel rails was 1,036,353 gross tons, being 424,379 tons, or 30 per cent. less than in 1892. In the first half of the year there was produced 704,240 tons, and in the second half only 332,113 tons. The production of Bessemer steel rails in the United States in 1893 was the smallest since 1885.²

Production of
Bessemer in-
gots and rails
in United
States.

*The Engineering and Mining Journal, Feb. 3, 1894, pp. 114-115.

²The Iron Age, Jan. 25, 1894, p. 156.

Lake Superior
iron ore pro-
duction.

The Iron Trade Review publishes the following table, showing the quantities of iron ore from the several ranges of Michigan, Wisconsin and Minnesota, carried down by lake freight in 1892 and 1893 :

Ranges.	1892.	1893.
	tons.	tons.
Marquette	2,666,856	1,829,053
Menominee	2,231,499	1,466,197
Gogebic	2,973,993	1,329,464
Vermilion	1,167,650	820,621
Mesabi	4,245	613,620
	9,074,243	6,058,955

Add all rail shipments of both years and the totals of production are 9,603,173 and 6,236,992 tons respectively—showing a decrease in 1893 of 3,366,181 tons, or 35 per cent.³

Penokee and
Gogebic Con-
solidated
Mines in the
hands of re-
ceivers.

On 11th January, 1894, the Penokee and Gogebic Consolidated Mines passed into the hands of receivers by order of the Court at Madison, Wis. This company controlled what is known as the Colby group of mines, which includes the Colby, the Palms, the Tilken and Comet iron mines in Michigan and the Superior mine in Wisconsin, all on the Gogebic range. An action begun by the Farmers' Loan and Trust Company of New York to foreclose a mortgage of \$1,000,000 on the company's property was the immediate cause for appointment of receivers. The mines could have shipped this year a million tons of ore, more than half of which is ready for delivery ; but there is no market. The Penokee and Gogebic Consolidated Mines are consolidated at \$6,000,000, and among the principal stockholders are the Rockefellers.⁴

Dunn Mine,
Lake
Superior.

The Schlesinger syndicate, operating the Dunn mine on Menominee range, Wisconsin, ran behind during the depression of last year, and among the obligations unpaid were \$22,000 for royalties and \$10,000 freight to the Chicago and Northwestern Railway. The leasehold, for which the syndicate had paid \$80,000, was recently sold under the hammer and was bid in by the railway for \$28.⁵

An iron town
sold out.

Fort Payne, Alabama, has been sold at public outcry for \$60,000. The purchase includes 30,000 acres of mineral lands, 2,000 town lots and various industries, including the rolling mill and furnace of the Fort Payne Coal and Iron Co. It is said that the private and corporate expenditures amounted to \$5,000,000, and of the Port Payne Coal and Iron Co. alone to \$2,000,000. Yet all this property has been sold for \$60,000. The town was founded by New England capital in 1889.⁶

The Pittsburg
iron workers.

As further evidence of the depressed condition of the iron trade in the United States is an approximate estimate, prepared by the Pittsburg Press, of the number of men in the main iron works employed in the Pittsburg district. It shows that out of 56,956 men employed by 68 firms reported when working full time, only 26,413 were employed at the beginning of the present year.⁷

³The Iron Age, Jan. 25, 1894, p. 157.

⁴The Iron Age, Jan. 18, 1894, p. 100.

⁵The Iron Age, Jan. 18, 1894, p. 100.

⁶The Iron Age, Feb. 1, 1894, p. 220.

⁷The Iron Age, Jan. 18, 1894, p. 113.

X.

NICKEL STEEL FOR ARMOR.

One of the most promising uses of nickel continues to be as an alloy with steel in the manufacture of armor plate. Yet the superiority of nickel steel is not so uniformly admitted as to make the general adoption of it by Governments certain. In the United States there is no doubt in the mind of naval experts that the nickel steel plate surpasses all others in capacity to resist attack ; and although discredit has been temporarily brought upon it by the dishonesty of certain parties employed in the manufacture of plate, there can be no doubt that a high degree of perfection has been attained in that country in the production of an alloy possessing admirable qualities. This is especially true of the nickel steel plate produced at the South Bethlehem works, as has been proven many times over by the severe tests to which it has been subjected. On the continent of Europe also, much attention has been given by Government officials and the heads of great iron and steel works to new processes of alloying and treating the metals : but perhaps with the single exception of the Krupp works in Germany the degree of success reached in the United States has nowhere else been attained. It is in Great Britain alone that claims are made of the superior excellence of all-steel plates, and the naval authorities of that country maintain that steel treated by the Harvey process has given even better results than nickel steel subjected to like treatment. It may be questioned however if in alloying nickel and steel for use in the manufacture of armor the quality is equal in all respects to the product of United States works. American experts assert that it is not, as has been shown by trials of armor in the two countries, and claim furthermore that the larger experience they have had in the manufacture and treatment of nickel steel entitles them to speak with some confidence upon its merits.

The merits of nickel steel and all steel in dispute.

The subject has an important interest to Ontario, because our nickel mines are one of the world's principal sources of supply of this metal ; and being more accessible than their only rival, the New Caledonia mines, they are likely to profit most by every increased demand for the metal.

Ontario's interest in the subject.

The papers which follow show pretty clearly the present situation of the controversy on the best material for the manufacture of armor plate. First in order is an extract from the Annual Report of the U. S. Secretary of the Navy for 1893. Then follows a paper by Mr. C. E. Ellis, (managing director of Messrs. John Brown & Co's Atlas Works), read at the British Institution of Naval Architects, 15th March, 1894, in which the records of numerous tests are given to show the excellence of all-steel armor treated by the Harvey process. Third in order is an extract from an editorial article in the

The situation of the controversy.

London Engineer of March 23rd, 1894, commenting upon the paper of Mr. Ellis and upon one read at the same meeting by William H. White, C.B., of the British Admiralty service, asserting the claim that "at the present moment England is taking the lead both in armor and ordnance." The fourth article is a reply to Engineer by Captain Jaques, Ordnance Engineer of the South Bethlehem Iron Works, which Engineer commented upon but declined to publish. By the favor of Captain Jaques it is published in this Report for the first time.

UNITED STATES TESTS OF ARMOR PLATE.

Tests at Indian Head proving ground.

"The tests of armor plates at the naval proving ground at Indian Head during the past year have been most important, some exceeding in severity any ever attempted either in this country or abroad. The results of these tests have been conclusive in demonstrating the desirability of using the Harvey process for the armor of all the vessels now under construction. In one test, that of a 14-inch nickel steel Harvey plate, the results were remarkable. Against this plate were fired four 10-inch Holtzer armor-piercing shells, with striking velocities of 1,472, 1,859, 1,959, and 2,059 foot-seconds, respectively. All four of these projectiles were crushed on the plate, the greatest penetration, which did not exceed 11 inches, being that of the last shot, which was fired at a fragment of the plate weighing but 4.4 tons with a striking energy of 14,715 foot-tons, or 3,344 foot-tons per ton of plate attacked. It is believed that such an energy per ton of plate has never been used in any test.

Tests of treated and untreated nickel steel plates.

During the tests for acceptance of armor plates experiments have been made to determine the relative effects of impact of armor-piercing projectiles on ship's framing protected by ordinary nickel steel plates and by nickel steel Harveyized plates. In the experiments the backing representing the ship's framing was the same in each case.

The untreated nickel steel plates receive nearly all the energy within themselves, and distribute it over the vessel in racking effect, while the hard surface of the nickel steel Harveyized plates causes the energy of impact to be principally absorbed in the disintegration of the projectile. The experiments developed a marked difference in the effects produced, in one case a much heavier nickel untreated plate being set back bodily several inches under impact of 100 foot-seconds less velocity than the lowest striking velocity with which the Harvey plate was attacked, while the latter was scarcely moved at all.

During this year all the armor delivered has been of nickel steel, the tests of which have shown ballistic qualities decidedly superior to what is required for acceptance under the terms of the contracts.

Beneficial results of the Harvey process.

Exhaustive experiments have conclusively demonstrated the beneficial results obtained by the application of the Harvey process, and arrangements have recently been made to Harveyize such of the armor under the old contracts as was not too far advanced in manufacture to admit of the change, or as would not seriously delay the completion of the ships. In consequence

of this, much of the side armor of the Maine, Texas, Indiana, Oregon and Puritan, the turret armor of the Maine, Puritan, and Monadnock, and the barbettes for the Oregon will be of Harveyized nickel steel. All the armor provided for under the new contracts will be treated by the Harvey process.

At the present time this country is no longer alone in the manufacture and use of nickel steel and nickel steel Harveyized armor, its initiative having been followed by many foreign powers. Compound armor has been abandoned by the German naval authorities, and that country will hereafter employ nickel steel, and it is believed that Krupp of Essen is using a surface-hardening process similar to that of Harvey. Nickel steel Harvey plates have been very successfully tried in England and Russia, and experiments are going on in France and Italy with a view to having its manufacture domesticated in those countries. The right to use the Harvey process has been secured by an Austrian firm, and the necessary furnaces are now being installed in that country. Nickel steel armor has been steadily growing in favor in England, and a syndicate, including the principal armor firms of that country, has purchased the right to use the Harvey process."¹

Adoption of nickel steel armor by European powers.

ELLIS ON RECENT EXPERIMENTS IN ARMOR.

At the meeting of the British Institution of Naval Architects in March the following paper was read by Mr. Charles E. Ellis of the armor-making firm of John Brown & Co. of Sheffield.

"The importance of any discoveries which will increase the defensive power of any given thickness of armor as disposed in modern battleships is so great that no apology is needed for introducing this subject to the Institution. By the kindness of the council I have been permitted to lay before the members a few remarks on the history of the latest developments of the attempts made by manufacturers to furnish a plate equal to cope with the improved armor-piercing forged steel projectiles, which at one time threatened to carry all before them. The adoption of a new type of plate for three important battleships by the British Admiralty has brought the entire subject into considerable prominence, particularly in consideration of the extensive shipbuilding programme, which is apparently admitted on all sides to be necessarily undertaken in this country.

Armor plate and projectiles.

COMPOUND V. STEEL PLATES.

"I think the last paper of importance which was presented to the Institution was that of M. Barba, the chief engineer of the Creusot Works, and was read in March, 1891. In that paper, and in the comments upon it made at the meeting, the merits and demerits of steel as against compound armor were fully discussed, and I think I am not going too far in saying that the general opinion was that for all practical purposes compound armor still held the field. It was felt that the acknowledged superiority of this type over steel in (1) offering greater resistance to projectiles of medium quality, as admitted by M. Barba himself, and (2) withstanding the attack of shot fired

Steel and compound armor.

¹ From Secretary Herbert's Report for 1893, pp. 27-28.

obliquely, was such that, in spite of the excellent results obtained both by Messrs. Schneider and by Messrs. Vickers in all steel plates, the compound plate was, under all the circumstances, preferable. The then recent tests on board the *Nettle*, which were under review at this period, are however valuable at the present time as forming a standpoint from which we can estimate the extent of later improvements.

Comparative
tests of six
years ago.

I take as examples the compound plate of Messrs. Cammell tested on March 24, 1888, and the steel plate of Messrs. Vickers tested on September 6, 1888. Each trial was made under the ordinary *Nettle* conditions. The plates measured 8 ft. by 6 ft. by $10\frac{1}{2}$ in., and were attacked by the 6 in. breechloading gun, firing three Holtzer projectiles of 100 lb. in weight, and two Palliser shot of 98 lb., with a striking velocity in each case of 1,976 foot seconds, giving according to the Gavre formula a perforation in wrought iron of 11 in., and according to De Marre's formula of 13 in. The resistance of the compound plate to each of the Holtzer projectiles was about the same. Each of the shot stuck in the plate, being much split up, the base projecting in each case from $5\frac{1}{2}$ in. to $6\frac{1}{2}$ in. from the face, and bulges were formed at the back of the plate about 2 in. in height. The length of the Holtzer shot is $17\frac{1}{2}$ in., and judging from the back of the plate and from the fact that the shot was somewhat set up, it is not unreasonable to suppose that the penetration in each case would be from 9 in. to 10 in. The plate developed several superficial cracks, but these were not at all serious. In the Vickers steel plate the penetrations were ascertainable in each case, being 13.5 in., 13 in., and 13 in. respectively, with bulges at the back of the plate from $2\frac{1}{2}$ in. to $3\frac{1}{2}$ in.; the projectiles rebounded entire, two of them being slightly distorted and set up. Three short through cracks were formed, but the plate remained entire. It is not necessary for my present purpose to consider the effect of the Palliser shots at these trials, beyond saying that each of the plates stood up well against them. I have taken these plates as favorable illustrations of the armor of the period—1888-91—when M. Barba's paper was read, and I shall now endeavor to show what increase of resisting power has been obtained in some of the later inventions or improvements in manufacture.

Cammell steel
and nickel
steel plates.

Dealing first with steel plates, I must refer to some trials of Messrs. Charles Cammell & Co., who, although fully occupied at the time with the manufacture of compound armor, achieved considerable success in their experiments with steel. Following up a successful trial of an all-steel plate at Portsmouth in May, 1888, they presented further plates for test in December, 1891, and in May, 1892, which were characterized by excellent quality of steel. Under the usual conditions of a *Nettle* trial each of the plates successfully stopped all the projectiles without any cracking whatever. The penetrations, as might be expected, were considerable, the greatest being about 14 in.; but there could be no doubt that a uniformly excellent plate had in each case been presented. The same firm was also successful in the manufacture of nickel steel plates, which were so largely used for the secondary armor of the Royal Sovereign class of battleship. The tests upon which these plates were selected were under the following conditions: The plate, 4 ft. by 4 ft. by 4 in., was not backed, and was attacked by

three Palliser 5-in. projectiles of 49 lb. in weight, with a velocity of 1,200 ft. per second. In the most successful trials none of the shot perforated the plate and no cracks were found. For this class of armor there can be no doubt that the alloy of nickel proved most beneficial in providing the peculiar toughness requisite when the plate is unbacked. My own firm were also successful at the same trials, which were competitive, in producing good nickel steel plates, and were allowed, with Messrs. Cammell, to provide the secondary armor for the battleships above named.

An excellent plate, manufactured by Messrs. Vickers, was tested at Ochta in November, 1890; but, as the results of that trial are so well known, I pass on to give some particulars of the results achieved by the Continental ^{Vickers} plates. manufacturers in recent trials of steel armor.

I regret I have no records of any of the plates of Messrs. Schneider other than those which have appeared in the public press. I wish however to refer to the Texel trial of August, 1893, when this firm was represented. The conditions of the trial were the same as in the case of the Harveyed plates of the same trial. In the result Messrs. Schneider's plate was perfor- ^{Schneider} ated by two of the shots, but broke up two of the remaining three, one of these being fired with the highest velocity. The remaining shot, which was fired at the lowest velocity, rebounded intact. The plate, which appeared to have been face hardened, exhibited no cracks whatever. Another interesting trial of the nickel steel armor of the same firm was held in the summer of last year, when a test plate for the armor being made for the Tri Sviatitelia was very successful. The conditions of acceptance were that the plate should receive four blows from Holtzer projectiles of 317 lb. from a 9.4 gun, with a velocity of 1,945 f.s., without any portion of the plate being broken off, while in no case was the base of the projectile allowed to penetrate the target to a depth of as much as 7.8. Through cracks were permitted. The plate measured 8 ft. by 8 ft. by 15.9 in., and from the account in the Engineer (15th September, 1893) successfully passed these severe conditions, the greatest penetration being 14 in. No serious cracks were produced.

The St. Chamond Company, in addition to some successful trials of Harveyed plates, which I will not deal with here, has been singularly successful in the production of a steel armor plate of great toughness and uniform ^{St. Chamond} character; and I have the particulars of those trials where this is most apparent. In April and May, 1892, a plate measuring 8 ft. 3 in. square, and 10½ in. in thickness, successfully withstood nine steel 6-in. projectiles weighing 100 lb. each, fired at a velocity of 2,149 ft. per second, without being perforated and without any cracks whatever being formed, except in the bulges formed by the projectiles. Judging from the two cases where it was possible to measure them, the penetration did not exceed 12⅞ in. At the trial at Ochta in December, 1892, the same company exhibited a most interesting example of this class of armor. The plate measured 8 ft. by 8 ft. by 10 in., and six shots weighing 87 lb. were fired at it from a 6-in. gun, at a velocity ranging from 2,177 ft. to 2,198 ft. per second. The penetration varied from 11¼ in. to 12 in., proving the uniform character of the steel, and no cracks whatever appeared in the plate. The calculated perforation

in wrought iron of the shot is according to the Gavre formula 11.7 in., and according to De Marre's formula 13.8 in. A further trial of a similar plate was made at Texel in August last, but as an account has so recently been given of the results in the Engineer (19th January, 1894), it is not considered necessary to do more than to say that the Ohta results were fully confirmed.

Chatillon
Commentry
plates.

Another French firm, the Chatillon Commentry Company, has devoted considerable attention to the manufacture of deck armor, with excellent results. I have the particulars of a trial where, in a plate of 5 ft. 3½ in., by 4 ft. 11 in. by 2¾ in., nine 100-lb. shots were fired from a 6-in gun at a square in the centre of the plate, the side of the square measuring only 15½ in. The velocity was of course low, being 535 ft. per second; but the peculiarity of the trial was that only one fine crack was formed between two of the points of impact. The same firm have also been experimenting with Harveyed armor, with the satisfactory results mentioned below.

German
nickel steel
plates.

Of the German manufacturers, Messrs. Krupp exhibited at Chicago several excellent plates, of which I select two for illustration here. The first is a nickel steel plate measuring 12 ft. by 8 ft. by 15¾ in. Four Krupp's steel and one chilled iron projectile, weighing 718 lb. each, were fired from a 12-in. gun, with a velocity of about 1,690 ft. per second. The chilled shot broke up and stuck in the plate, while the four steel projectiles were thrown back broken. The greatest penetration was 19.6 in., and the plate remained free from cracks. On 13th March, 1893, a 10½-in. nickel steel plate (hardened) was tested with excellent results. Five Krupp's steel projectiles were completely broken up without cracking the plate in any way. The particulars of the rounds are as follow :

	Round 1.	Round 2.	Round 3.	Round 4.	Round 5.
Gun.....	5.9 in.	5.9 in.	5.9 in.	8.26 in.	8.26 in.
Weight of shot	112 lb.	112 lb.	112 lb.	209 lb.	307 lb.
Velocity.....	1,885 f.s.	2,000 f.s.	2,160 f.s.	1,727 f.s.	1,824 f.s.
Penetration...	2.7 in.	Not measur- able.	12.2 in.	4.5 in.	Not measur- able.

The trial is interesting, inasmuch as the behavior of the plates resembles closely that of the Harveyed plate, but it is evident that the shot was considerably overmatched.

The old-established firm of the Dillinger Huttenwerke Company has also given favorable examples of nickel steel armor, exhibiting the same absence of cracking which has characterized so many of the trials of this class of armor. I append the particulars of the tests of two plates which are worthy of notice.

Trial, 9th February, 1893 : 8¾ in. nickel steel.

Round.	Projectile.	Weight of projectile in lb.	Velocity in f.s.	Penetration in inches.
1	Steel, 6 in	112	1,554	10.5
2	"	112	1,543	10.8
3	Steel, 8¾ in	209	1,454	11.5
4	"	210	1,447	12.2
5	Chilled iron, 8¾ in.....	209	1,442	9.6

Steel plates are also being successfully manufactured in Russia, Italy, and in Austria; the firm of Witkowitz in the latter country having been recently successful in the Pola trials. An account of these trials has so recently appeared that I need not give any particulars.

The above remarks show that, since the reading of M. Barba's paper before the Institution, a considerable impetus has been given to the manufacture of steel armor, and I have endeavored to give the results of the best examples of each manufacturer's plates in order to show what progress has been made. It will be noticed that, with one or two exceptions, none of the plates are hard enough to break up armor-piercing projectiles, which is the special characteristic of the modern Harvey armor yet to be noticed. As long ago as 1883 Admiral Acton, the Italian Minister of Marine, in explaining to the Chamber of Deputies the reasons for the preference of the Government for compound armor to steel, said that if the face of the steel could be successfully hardened it might possibly be most successful in the future, and Captain Orde Brown in the pages of the Engineer, has for some time advocated the application to steel of the principle of hard faces and soft backs, as seen in compound armor. As will be seen, this desideratum has now been obtained, but before examining the results of the trials of the new Harvey plates, I must first treat of the experiments of compound armor plate manufacturers subsequent to the trial of the standard plate of Messrs. Cammell, above described. Although the question has apparently ceased to be of practical interest, a few instances of the improvements effected in increasing the hardness of the faces of compound armor may here be given.

Passing over the Dutch trials of November, 1889, where a compound plate made by my company broke up two forged steel Krupp projectiles, in the words of Captain Orde Browne, "like chilled iron," I come to later experiments. Mr. Alexander Wilson has shown me a photograph of a 10½ in. compound plate, manufactured by his firm, which was tested in August, 1891, and completely broke up three 6-in. A.P. projectiles, and two 6-in. Pallisers, fired with a velocity of from 1,956 ft. to 1,974 ft. per second. I am not able to give the penetrations, but beyond two unimportant cracks the plate was apparently uninjured.

"I must now mention some experiments made by my own company in the same direction. The attention of my friend Captain Tresidder had been drawn to the importance of endeavoring to break up the point of a steel projectile before it had time to effect any degree of penetration into the plate sufficient

“ I must now mention some experiments made by my own company in the same direction. The attention of my friend Captain Tresidder had been drawn to the importance of endeavoring to break up the point of a steel projectile before it had time to effect any degree of penetration into the plate sufficient

to cause perforation or serious damage by cracking. With this object in view, he tried various methods of rapidly chilling the face of armor plates; and, after obtaining fairly satisfactory results with cold air and steam impinging along the face, he directed his attention to the best way of hardening armor by means of a sudden uniform process of chilling by water. The process devised by Captain Tresidder was, and is, applicable and beneficial to all kinds of plates; but naturally, it has its most striking effect where carbon is present in sufficient quantity to ensure absolute hardness. My company being at the time large manufacturers of compound armor, Captain Tresidder's earliest experiments were conducted with that class of plate; and, although it subsequently became apparent that the hardening process was more suitable to homogeneous than to built-up or compound plates commonly so called, the results of one or two of the trials are sufficiently interesting to deserve mention. The nature of the invention may be stated in a few words. It consists in the application of water under such pressure and of such volume as will effectually prevent any envelope of steam forming on the face of the plate, this ensuring a rapid chilling and resultant hardness uniformly over the surface of the plate.

results obtained from it.

The experiments were, so far as the chilling process was concerned, uniformly successful; but for my present purpose I only trouble the Institution with the consideration of one trial which took place at Shoeburyness on August 4, 1892. The dimensions of the plate were 8 ft. by 6 ft. by 10 in., and it was attacked by five 6-in. Holtzer projectiles, weighing 100 lb. each, with a velocity of 1,976 ft. per second. Captain Orde Browne describes the result of the trial as follows: 'The whole of the projectiles broke up with very little penetration. The plate, after the trial, appeared to be nearly as stiff and as strong as at first.'

Similar results were obtained in numerous other trials, the marked feature in each case being the complete breaking up of the best forged steel armor-piercing projectile in the same manner as the old compound plates had invariably broken up chilled Palliser shot. Of the value of the invention as a step in the development of armor there can be no doubt, but experience soon proved that its efficacy would be more strongly demonstrated by applying it to homogeneous steel plates, highly carbonized on the face, armor which has now generally become known as Harveeyed armor.

The Harvey treatment

The late Mr. Harvey unfortunately died just at the time when the results of his plate had become known and acknowledged in Europe. Having successfully applied to smaller articles the system of cementation or conversion followed by chilling, he directed his attention to the effect of similar treatment in the case of homogeneous steel armor plates. A series of experiments was made under the auspices of the United States Government, and the results were from the first of a very encouraging description.

adopted by the British Admiralty.

Inasmuch as this armor has been definitely adopted by the British Admiralty for the three important battleships now building, I have thought it would be interesting to the members of the Institution to give a detailed account of nearly all the trials that have been made of it in this country and abroad.

The list includes the earliest American trials of the Bethlehem Iron Company and Carnegie, Phipps & Co., and the first Harveyed plate manufactured in Europe, that of Messrs. Vickers, tested in November, 1892.

It is no part of my purpose to draw comparisons between the plates of rival manufacturers. I desire rather to call attention to the results obtained by this class of plate in the various trials taken as a whole, in order to demonstrate the extent of the improvement in armor realized by the new process. The British tests appear to be most useful for this purpose, and, with the authority of the Director of Naval Construction, and the consent of the other English manufacturers, I am able to give full particulars of all the British trials.

BRITISH TRIALS OF HARD-FACED ARMOR.

"Speaking generally, the American trials are characterized by conditions rather more favorable to the plate than to the shot, while in France, with one or two exceptions, the reverse has been the case. In England however, and in some of the trials made abroad, the authorities appear to have gauged most accurately the resisting power of the Harvey plate to the blow to be delivered, with the result that in many cases the shot and the plate appear to be equally matched. A good instance is to be found in the trials of Messrs. Cammell's and Messrs. Vickers' 6-in. steel plates on the Nettle. An examination of these trials will show that, with the highest velocity (1,960 ft. per second), a 6-in Holtzer projectile was unable to perforate the plates, damaged as they had been by two previous rounds. According to the Gavre formula, this shot would have perforated 11 in. of wrought iron (or 13 in., according to De Marre's formula), so that we get a superiority to wrought iron of at least 183 per cent. Other instances may be found in the nickel steel 10½-in. plate of Messrs. Cammell, and in the nickel steel plate of the same thickness made by my own company, tested at Shoeburyness on 9th November and 10th October, 1893, respectively. The Cammell plate was curved to moulds supplied by the Admiralty, and was only penetrated to the depth of 10 in. In the Brown plate the projectile stuck in the plate, broken, and we may assume that each of the plates was a fair match for the blow delivered. The gun used was the 9.2, and, with a Holtzer shot of 380 lb. and a velocity of 2,035 ft. per second (the highest obtainable), a striking energy was obtained of 10,900 foot tons. These conditions would give, according to the Gavre or De Marre's formula, a perforation in wrought iron of 22 in. or 22½ in., showing for the plates in question a superiority over wrought iron of 209.5 per cent., at least. Again, the Chatillon Commentry 6.7-in. plate gives an excellent example of a trial where the conditions of attack and defence approximate one another.

Taking the severest blow, we find that the plate was not perforated by a shot which would, according to the Gavre formula, pierce a wrought-iron plate of 11.9 in., and according to De Marre's, a plate of 13.8 in. in thickness; in other words, showing a superiority over wrought iron of 177 per cent. according to the one, and of 205 per cent. according to the other formula.

It was at first assumed that the Harvey process was considerably better adapted to nickel steel plates than to all steel, and this is still no doubt the

American tests of low and high carbon nickel steel plates not accepted in Great Britain.

The extra cost of nickel,

and the quality of extreme hardness it imparts to steel.

Adapting the Harvey process to curved and twisted plates.

general opinion in the United States. In the Annapolis trials of 1890 the Schneider nickel steel plate was undoubtedly superior to the all-steel plate made by the same firm; and in a trial of 3-in. plates in May, 1891, the nickel steel Harveyed plate was stated to be better than the all-steel plate. In the Indian Head trials of the same year, the low carbon all-steel Harveyed plate of the Bethlehem Company was placed considerably below the high carbon nickel steel Harveyed plate of the same company; but in this case the consideration of the question was complicated by the difference in the carbons, as it is probable that a nickel steel plate would not require to be so high in carbon as an all-steel plate to give the same resistance. Since this trial however it seems to have been assumed in the United States that all Harveyed plates should be made of nickel steel. In Great Britain however the high cost of nickel has caused manufacturers to turn their attention to producing Harveyed steel plates containing no nickel, and an examination of the details of the various trials shows that all have succeeded in proving the reverse of the theory accepted in the United States. There may perhaps be a slightly greater tendency to crack in the all-steel than in the nickel steel plates, as tested in this country, but this is more than compensated for in the superior resistance to penetration. The 6 in. Portsmouth trials all demonstrate this fact, and attention may also be called to the trial on 26th October, 1893, when experiment showed that the 10½-in. Brown all-steel plate more effectually broke up the 9-in. shot than was the case in the similar trial of the nickel steel plate under the same conditions. The expense of the addition of nickel renders this question of such importance that I regret there are no foreign trials available for providing further demonstration, if such be needed.

Apart from the question of extra cost, there are also practical considerations which affect the point in question. Some experiments made by Captain Tresidder show that a steel plate containing an ordinary percentage of nickel and a high percentage of carbon is practically unmachinable. If therefore a nickel steel plate be taken containing, say, 3 per cent. of nickel, and it be super-carburised up to, say, 1 per cent., its face will be so hard (even before the chilling process is effected), that for all practical purposes it will be impossible to drill and tap the various small holes that are nearly always necessary to be made on the face of the armor plates for ships' sides. In the case of steel armor, this difficulty (which I believe has already arisen in the United States in the case of nickel steel plates) does not exist, and thus one important objection to the adoption of the Harvey process for ship's plates as required by naval architects has been overcome by its application to all-steel armor in place of nickel steel.

I must now allude to the doubts that have been expressed as to the difficulties which will be experienced by manufacturers in adapting the process to curved and twisted plates. Both the Dutch and the Austrian Governments appear to have attached great importance to this consideration. No doubt there are, and will be, difficulties caused by the warping effect of the water treatment, and time alone will show whether they are as serious as the detractors of the system allege. I think however—and I am sure I can speak for the other armor plate manufacturers in this country—that any

difficulties thus created will be readily overcome. In the first place, if a plate is uniformly heated, and uniformly chilled, any alteration of its form will also be uniform. A very little experience therefore will teach the operator the lines on which to work, particularly if the system of chilling in use is of a suitable character. We know also that the side armor for the Maine, made by the Bethlehem Company, has been accepted by the United States Government; and, although I have no accurate information on the point, we may safely assume that the plates were not straight. Both Messrs. Cammell and my own company have also successfully made sample Harveyed plates to moulds having both curve and twist, and probably other manufacturers have done the same.

It may be interesting to give an account of some mechanical tests showing the quality of the soft parts of Harveyed plates which have been successful in trials. In the early stages of our experiments a 4 ft. by 4 ft. by 9 in. plate was tested at Shoeburyness, breaking up the 6-inch Holtzer in the usual way without cracking. Test pieces were taken from the back of the plate with the following results:

	First specimen.	Second specimen.
Breaking strain per square inch	31 tons	30 tons.
Elongation per cent. in 2 in	31	31
Reduction of area per cent	57	61
Cold bends without fracture	180°	180°

Mechanical tests of soft parts of plate

The plate, it may be mentioned, was not of our special armor plate quality. It gives however a sufficient indication that, apart from the face, the body of the steel does not, at least, suffer from the application of the process.

One characteristic of this kind of plate must be specially mentioned . . .

I refer to the extraordinary resistance given to shot by small fragments of plate only. Perhaps the most conspicuous instance of this is given by the Bethlehem 14-in plate of 11th February, 1893, where a 10-inch Holtzer projectile was fired, at a velocity of 2,059 ft. per second at a piece of plate weighing only 4 1.5 tons, and was broken up with a penetration of 11 in. The total striking energy of the blow was 14,715 foot-tons, or 3,344 foot-tons per ton of plate. Another example may be found in a recent trial of a 6-in. steel plate made by my company. The fourth shot of this trial was fired nearly at the centre of the plate, after cracks had been made, such that the point of impact was about the middle of an equilateral triangle, with each side measuring about 2 ft. The 6-in. shot, with a velocity of 1,815 ft. per second, was completely broken-up; one small crack only was made, and the fragment of plate represented by the triangle, dished to the extent of an inch, showing the tough nature of the material. If therefore the Harvey plate be broken up, but its fragments still adhere to the backing, it still presents a considerable resisting power. It seems however from the foregoing remarks that it might be desirable to have a greater number of bolts per square foot of plate than was the case in the old form of armor.

Resistance to shot by fragments of plate

EXTENT OF THE IMPROVEMENTS.

Estimate of
the increased
value in manu-
facture of
armor-plate
since 1888.

"With the above facts before us, we are enabled to form some idea of the improvements that have recently been effected in armor-plate manufacture, and of the relative value of the various kinds of armor. Without disregarding the excellent qualities of the steel and nickel plates which I have alluded to earlier in this paper, I think I have shown that Harveyed armor would be a more efficient defence to the vital parts of any ship of war, whether battleship or cruiser, than any other type of plate. Opinions may differ as to the percentage of superiority it possesses, but I do not think I am over-estimating its value when I place its resisting power at 50 per cent. above the steel and compound plates of 1888, which I have chosen as the basis of comparison. This advantage can be used by the naval architect in one of two ways: he can either clothe with armor a greater part of his ship, or he can obtain greater resistance, keeping the same thickness of armor. The new development is therefore of the greatest importance, and it will be a matter of satisfaction to this Institution that the British Admiralty have been the first naval authority in Europe to realize the value of this new form of armor, and to apply it to their most recent designs."²

IS GREAT BRITAIN TAKING THE LEAD?

Commenting on a paper read by Mr. William H. White, C.B., at the meeting of the Royal Institution of Naval Architects (March 15), London Engineer deals with the claim that "at the present moment England is taking the lead both in armor and ordnance," examines the ground on which the statement is based, and thinks it is possible that Mr. White may have referred to the continent rather than America.

Superiority of
the Harvey
system.

"The superiority of steel armor test plates treated on the Harvey system," it says, "to the untreated plates preceding them has been so abundantly established in this country that, in speaking of the question on its own merits, without any thought of continental armor, the only doubt is whether to credit the improvement as having amounted to 50 per cent. or some much higher figure." Having examined Mr. White's claim as to superiority over continental armor, the Engineer proceeds to say:

Severe tests
adopted in the
United States.

"The question on which most light was thrown incidentally by the facts which came out in discussion is the comparison of English Harveyed plates with those of the United States. Both in the use of nickel and in the Harvey process the United States were in the field before us. They tested their Harvey plates with 8-in. Holtzer steel shot; while we were attacking our compound plates, treated by the Tresidder process, with 6-in. shot only. Their plate trials have been in the very front as to progress. Last year they tested magnificent nickel steel plates with Carpenter projectiles made in America, which put to shame the Holtzer shot fired on the same day, although the latter were of smaller calibre, and therefore easier to manufacture. It needs then very clear evidence to establish a claim of superiority as compared

² Charles E. Ellis at the Institution of Naval Architects, 15th March, 1894, published in *Industries and Iron* 8th June, 1894, pp. 669-71.

with the United States, even for a moment. We think however that the following points may be urged, although we speak doubtfully. Since the introduction of the Harvey process in England we have increased the severity of the tests; in fact, discovering what could be learned by repeatedly testing plates to destruction; and investigation has led to the conclusion that Harveyed steel plates without any nickel in their composition are slightly superior to those containing nickel, their resisting power to penetration being greater, although their toughness is less. In the United States nickel is used in all plates, but it is doubted whether thick plates can with advantage be subjected to the Harvey process. Without giving a distinct reason, the makers seem reluctant to subject their thick plates to the prolonged high temperature which is needed, urging generally how undesirable it is to do so unless the gain is very great; while they point out that the good effect of water-hardening and carbonization is necessarily limited to a depth which tells much less on thick than on thin plates. In addition to this we have heard that trouble is caused in America by the difficulty of drilling holes in the faces of their hard plates. In the discussion which followed the reading of his paper, Mr. Ellis stated two facts bearing on this: one that the presence of nickel causes steel to crystalize at a much lower temperature than it would otherwise, and the other that the 'arc light' system of drilling is not applicable to plates containing a high percentage of carbon and nickel together. It seems then a natural conjecture that the nickel in the United States plates has given trouble both in the Harvey process and in the process of drilling, which trouble we have happily avoided owing to the decision to dispense with its use. If this is so we shall find that the United States soon follow our example, and we may in the meantime be said to have the lead that Mr. White claims; although we acknowledge that whatever may be the dislike to apply the Harvey process to thick armor, extraordinary results have in one instance been achieved by a United States Harvey plate 14 in. thick. We have also to admit that the remarkable series of successes achieved by Harveyed plates, conclusive as they are as to firing for experiment, have as yet not convinced the continental powers that they ought to adopt them, because the process causes the plates to bend and alter slightly in form, and they are not satisfied that this can be so calculated and allowed for or so controlled as to admit of armor being fitted properly to the form of the ship's side. The answer was given to this objection that the United States ship *Maine* had been completed with her supply of Harveyed plates, that our own makers have now succeeded in making plates to a given curve, and that no serious difficulty is anticipated. We hope then altogether that at the present moment we stand in a very favorable position to furnish the new ships to be laid down with the best armor, and we trust soon to be able to give our readers detailed evidence with regard to our guns."³

The qualities of resisting power and toughness in steel and nickel steel armor.

Objections to nickel steel.

³ From London Engineer, March 23, 1894.

CAPTAIN JAKUES' REPLY TO ENGINEER.

The letter of Captain Jaques which follows was written from New York under date of April 19, and in its issue of May 11 the Engineer made lengthy editorial comments upon it, but adopted the very singular course of withholding publication. At my request Captain Jaques has supplied a copy for publication in this Report of the Bureau.

"Sir,—In your issue of March 23rd an editorial, discussing the claim that Great Britain has taken the lead in armor and ordnance, advances (with hesitation, it is true) opinions that ought not to be passed by without at least friendly criticism.

The British
critic and his
qualifications.

My response is based on the assumption that the article in question was written by one who has for many years handled this subject for Engineer, viz., Capt. Orde Browne. He is a most persistent student of this special branch of war material; is one of Great Britain's first authorities on armor; has the confidence of his Government and of the contractors; and has access to much information and the results of trials which govern his opinions, but the details of which he cannot always give to the public. Further, he is perhaps the best fitted of anyone in England to make a comparison between the tests of the two countries, as he visited our Naval Proving Ground at Indian Head last summer with me and witnessed the tests of nickel steel armor of 9 and 17 inches thickness, and had the opportunity to examine carbonized plates that had already been given their ballistic trials.

I note he has expressed himself very cautiously; this caution appears to be personal admission that the evidence which decided the opinions of Mr. White and the First Lord of the Admiralty was not sufficient to convince him.

The opinion expressed by Mr. White at the meeting of the Naval Architects on the 15th of March, and to which Capt. Browne has referred, was not a surprise to me, as he had expressed the same views in a discussion of the subject during my last visit to England.

Mr. White has gone into the armor question during the past few years with the purpose of securing a protection for the splendid ships he has designed, at least equal to the best in the world; he has carried on experiments on a liberal scale; and he has given me the satisfaction of seeing *steel* armor replace *compound* in the designs of his ships.

While therefore I have great respect for Mr. White's opinions, I am not yet ready to admit that Sheffield has acquired the standard that we have reached; and although Great Britain has, in relinquishing compound armor, made great strides to the front, she does not yet lead the United States in the production of armor.

Mr. Charles Ellis' valuable paper on the development of carbonized armor is a most pertinent one for his pen.

As general manager of the Works where his father first attempted the carbonization of heavy armor, he knows all the difficulties that deferred the adoption of this process; and no one appreciates more than he the value of our work at Bethlehem in bringing the process to the stage at which the Harvey Company exploited it.

VALUE OF NICKEL IN CARBONIZED PLATES.

"The special points however that have suggested my reply to Capt. Browne's editorial of March 23rd are the statements which refer to England's claimed lead in armor, and the comparative value of nickel in carbonized plates. In connection with the latter it will be interesting to recall two official statements published about the same time. Coming from such high authorities they will necessarily be accepted by a majority of the people of their respective countries. But as their conclusions are so diametrically opposite, we must examine the information that has been given to the public to see which opinion is most soundly endorsed.

Official statements and opposite conclusions.

The First Lord of the British Admiralty (Spencer) under date of March 10th, 1894, said :

'In the course of the experiments the use of nickel as an alloy of steel for the purposes of armor plates has been fully tested. It has been established that Harveyed plates without nickel in the steel show resistance to modern projectiles as great as any hitherto obtained when nickel was combined with steel in plates, also treated by the Harvey process. The consequence of adopting this new system will be a great saving in cost for a given defence.'

First Lord of the British Admiralty, and

The Secretary of the United States Navy, in his annual report dated November 18th, 1893, covers the statement of his Chief of the Bureau of Ordnance that—

'Recent experiments at the proving ground demonstrate conclusively that nickel armor will afford more protection than is generally supposed owing to the fact that the line of fire under service conditions will be at an angle to the plate which is most advantageous to the plate, and also destructive to the projectile. Nickel steel plates offer great resistance at this angular fire because of the extra toughness of this material as compared with ordinary steel.'

Secretary of the United States Navy.

How is this marked difference in the conduct of carbonized plates of plain and nickel steel to be accounted for?

Evidence of the records of trials.

Individual American plates still have the best record, unless perhaps we exempt one of Krupp's, and that was *nickel* steel supercarbonized by a process of his own.

The best and thickest carbonized service plates have been made in the United States and are of *nickel* steel.

Although England occasionally tests a plate of service thickness, her general practice of reducing plates to a thickness of six inches for ballistic acceptance, while supplying a uniform specimen for test and comparison, does not give results that will always hold true in plates of greater thickness, or be a guide for the valuation of the service plates themselves.

Increasing the number of bolts to keep cracked plates in position brings us back to the old discussions of which is the least objectionable, considerable penetration without perforation, or cracks. Each nation, as heretofore, will probably decide it from the point of view of its own experiments, as Mr. White has done from the action of his six-inch Nettle plates.

The attempts to demonstrate the value of nickel in steel have been very unfortunate in England, and the question naturally arises, Why is nickel steel so expensive as to preclude its use in England?

The United States steel workers have had better success with nickel than even French makers, and the evidence which the Krupp, St. Chamond, and Bethlehem eight-inch to seventeen-inch plates furnish as to the value of nickel in carbonized steel armor should certainly carry more weight than the results of the six-inch plates tested on board the Nettle, on which Mr. White's recommendations appear to be based.

The English armor plate makers are reaping the benefit of American accomplishment in carbonization. Perhaps when they learn the American methods of incorporating nickel, the value of that metal in steel armor will be as enthusiastically admitted.

Personally I have already expressed myself that the greater value of the carbonization was with the thinner plates; that—

‘Although the recent development has been chiefly in the direction of securing a harder face to the homogeneous steel plates, there still remains two types for comparison: that of a resistance which will keep out a projectile of any calibre if thick enough, and that which will destroy the projectiles until a calibre is reached whose smashing and racking energy will demolish the protection, although perhaps at the risk of its own destruction.’

But the results of the experiments reported in the annual report of the Secretary of the United States Navy for 1893, viz —

‘During the tests for acceptance of armor plates experiments have been made to determine the relative effects of impact of armor-piercing projectiles on ship's framing protected by ordinary nickel steel plates and by nickel steel Harveyized plates. In the experiments the backing representing the ship's framing was the same in each case. The untreated nickel steel plates receive nearly all the energy within themselves, and distribute it over the vessel in racking effect; while the hard surface of the nickel steel Harveyized plates causes the energy of impact to be principally absorbed in the disintegration of the projectile. The experiments developed a marked difference in the effects produced, in one case a much heavier nickel untreated plate being set back bodily several inches under impact of 100 foot-seconds less velocity than the lowest striking velocity with which the Harvey plate was attacked, while the latter was scarcely moved at all’—

reason for the carbonizing of plates of all thicknesses.

It will be interesting to compare the future ballistic results obtained with service plates of the two nations manufactured in accordance with the recently expressed official opinions. Up to the present time the United States has carbonized more armor and a greater variety of shapes and thickness than all other nations combined, and her experience points to the usefulness of nickel in the methods she employs.

In Engineer's issue of July 16th, 1893, Capt. Browne said of the test he witnessed at the United States Naval Proving Ground, July 11th of the same year, that ‘there is evidence here given that nickel armor has been probably perfected so as to resist fracture in a greater degree at Bethlehem than anywhere.’

This was spoken of uncarbonized nickel steel. The same can unquestionably be said of our carbonized nickel steel plates.

Relative
value of
carbonization
in thick and
thin plates.

Usefulness of
nickel estab-
lished by
United States
tests.

VALUE OF TOUGHNESS IN THICK PLATES.

"Mr. White has admitted that the toughness given by nickel is of great value when unbacked plates are used. When he tests the thick armor now ordered for the Majestic and Magnificent he may find that a plate receiving a blow from a 12-inch or 13.2-inch rifle will behave so much like Gruson chilled iron that nickel or some other alloy will be needed to keep the plate together.

Toughness a necessity to match the racking powers of large calibres.

The racking, disintegrating power of the larger calibres may make the employment of an element like nickel not only valuable, but an absolute necessity to secure the toughness which becomes of inestimably greater value in the thick plates.

Mr. Barba pointed out that the superiority of the nickel steel plate was as much, if not more, due to the great experience in treatment and manipulation as to the percentage of nickel alloy. Perhaps the English nickel steel carbonized plates are not as good as they can be made. The American who coached the British makers did not carry all of our experience with him.

The two facts mentioned by Mr. Ellis, 'that the presence of nickel causes steel to crystallize at a much lower temperature than it would otherwise,' and 'that the arc-light system of drilling is not applicable to plates containing a high percentage of carbon and nickel together,' have in no way interfered with our producing thick plates of carbonized nickel steel of a most attractive fine grain and fitted with as many holes and bevels on the hardened face and edges as the most exacting sailor or cabinetmaker could ask for.

If then the United States brought the present generally accepted type to the stage at which it is accepted by Sheffield; if we find no difficulty in carbonizing plates of seventeen inch thickness, if our carbonized *nickel* steel armor shows superior characteristics to carbonized *plain* steel, and if eight-inch and ten inch projectiles, when attacking at velocities over 2,000 ft.-sec. make no appreciable impression upon ten-inch and twelve-inch plates, Capt. Browne's hesitation to accept the statement of the Director of Naval Construction is well founded, and he is wise in waiting the results of the comparative test of thicker plates than six-inch before he yields that nickel has no marked value as an ingredient for the best armor.

Tests that suggest hesitation in accepting the British Admiralty's claim.

Until a four-ton fragment of fourteen-inch carbonized *plain* steel stands a 3,344 foot-ton energy per ton of plate with less penetration and cracking than did Bethlehem's fourteen-inch carbonized *nickel* steel plate, or a record is shown equal to that of Bethlehem's twelve-inch tapered ballistic test plate representing the side armor of the U. S. S. Maine, Great Britain can scarcely claim the lead in armor."

The Engineer of May 11 comments on Captain Jaques' letter (which it incorrectly states was published by him), and concludes by saying:

"Captain Jaques' letter is very moderate and fair. He readily accords full credit to the admirable Krupp plate exhibited at Chicago, yet we know that Krupp has been unfortunate since in one notable case. Altogether we think that it will be time to claim superiority over Bethlehem plates when they are beaten in fair competition."

and which Engineer is disposed to accept.

XI

DIAMOND DRILLS.

Introduction
of the diamond
drill for pros-
pecting pur-
poses.

Prospecting with the diamond drill was first tried in the coal fields of Pennsylvania in 1870, and this method of underground exploring has since been widely adopted to prove the extent of deposits of coal, iron and copper ores, gold, silver, etc. Where minerals occur in beds or large deposits, like coal and iron, the utility of this method of exploring is universally acknowledged. It has also been very serviceable in searching for gold, where it is found in blanket veins or in beds of auriferous alluvium, as in California and some parts of Australia; as well as in very large silver veins, like the Comstock lode in Nevada. But as regards the exploring of ordinary quartz veins carrying gold or silver, opinions differ.

To be used
with caution.

T. A. Rickard, M.E., who spent some time in Australia, says the diamond drill is often likely to do irretrievable harm by fostering delusive hopes on one hand or by unnecessary discouragement on the other. The explanation is, that often in gold-bearing veins the ore is pockety, and that a drill-bore may pass through one or more pockets, showing the ore to be very rich, or may miss them altogether, showing it to be worthless. "If the drill is to be used at all," Mr. Rickard says, "the dangers attendant upon its use should be minimized by planning a series of holes close together, so as to test thoroughly and satisfactorily at least a small portion of ground."

Government
drills in
Victoria,
Australia.

In the Colony of Victoria diamond drill prospecting for coal and gold is conducted under the control of the Department of Mines. In the report for 1891 Government Geologist Murray states that the total expenditure on boring since 1886 has been £30,000 for coal and £80,000 for gold. After summarizing the net results of boring for gold since the commencement of such operations, Mr. Murray says: "These results represent not only a very large amount of gold already won, but a still greater quantity the existence of which may be regarded as a certainty, and which will in due time be raised." The operations, it is considered, have been conducive to great economy of capital, as it has been practicable to select suitable sites for shafts in many places where otherwise it would have been necessary to trust to chance. "It may be fairly claimed," Mr. Murray asserts, "that not a single bore of the many hundreds put down has been utterly useless, with exception perhaps of some few that were sunk against the advice of the officers of the department, and the results even of these furnished useful experience for future guidance."

Cost of the
work.

In 1891 the number of bores with diamond drills in Victoria was 102, and the aggregate depth 26,991 $\frac{2}{3}$ feet, the total cost of which was for labor,

material and transit (exclusive of diamonds) £9.747 7s. 2½d., or 7s. 2½d. per foot. Inclusive of cost of wear and tear of diamonds, the cost per foot was 11s. 5¼d.¹

Another plan of Government aid in Victoria is by grants to companies or prospecting parties in opening up veins or deposits supposed to carry gold. The aid is made at a rate of 100 per cent. on the sum spent by the company or prospecting party, on condition that it shall be recouped if the mine is productive; but although £260,000 has been distributed in the six years 1886-91, the amount returned to the Government has been only £3,367. This fact, Mr. Murray says, speaks for itself as to the general non success of the system, justifying the assertion that the bulk of the money has been practically wasted "The money has been distributed and expended with little practical and no scientific result: in fact, had it never been voted it is probable that mining enterprise would have gone on just the same, or perhaps even better, without the enervating influence that the scramble for participation in the prospecting vote has undoubtedly exercised."

In New South Wales diamond drills are under the control of and are fitted up and worked by persons employed by the Department of Mines. The drills are carried on railways free of charge, but cost of removing from station and setting them up upon the site selected for the bore, and returning to station, must be borne by the persons desiring to use them. Before use of a drill can be obtained the applicant must guarantee cost of removal as afore-said, and fitting up at the site or mine, together with all charges for working the drill, including labor, loss of tubing, fuel, supply of water, repair of breakages, and £10 per week for wear and tear of machinery, destruction of diamonds, etc. The aim of the department is to work the drills in such a manner that the persons who employ them shall have their work done at cost price, and it is the duty of the superintendent to estimate the cost of each bore at such a rate as will just cover the amount. The total depth bored with six diamond drills in 1891 was 7,797¾ feet, the total cost of which was £5,825 14s. 6d., or 14s. 11¼d. per foot. The earnings of the drills are reported as £7,268 5s. 6d., or 18s. 8d. per foot, being a revenue above expenditure of £1,442 11s. But generally the accounts nearly balance. The diameter of bores is 3 to 4 inches.²

In Queensland two diamond drills were worked in 1891, but the results were not very satisfactory, owing in part to the broken nature of the rocks, but chiefly to the unpropitious character of the locations selected for boring.

¹In 1892 the number of bore holes put down for gold prospecting was 108, and the aggregate depth 27,272 feet; for coal prospecting, 20 bore holes and 17,574 feet. The aggregate cost of labor, material and transit for the former was £12,372 10s. 3d., and for the latter £8,339 12s. 1d., or at the rate of 9s. 0½d. and 9s. 5½d. per foot respectively. The cost for wear and tear of diamonds was 5s. 3¼d. per foot prospecting for gold, and 2s. 11¼d. for coal.

²In 1893 three borings were made with diamond drills, and the total depth bored was only 1,903 feet 7 inches, the decrease being explained as "solely due to the great financial depression under which the Colony is now suffering, as the Government drills are only worked at the expense of those who use them." The borings however were of great depths, being continuations of previous work. One was of 3 inches diameter, from 749 feet to 1,010 feet 7 inches; a second was 5 inches diameter from 1,875 feet to 2,356 feet, and thence 4 inches to 2,929 feet; while the third, of unspecified diameter, was from 87 feet to 675 feet. The average cost for boring, exclusive of office salaries, store wages, rent and travelling expenses of superintendent of drills, together with clearing bores, reaming and repairing, was 12s. 4¼d. The cost of wear and tear of diamonds, included in the above, was 3s. 3¼d. per foot.

"There can be no doubt," the report of the department states "that the selection of sites in future must be a matter of the greatest consideration, the mechanical part becoming of very secondary import. The choice of the best site resolves itself simply into a geological problem, and it therefore should devolve only on persons that are thoroughly versed in the geological structure of the locality to be operated on."

and Cape
Colony, South
Africa.

In Cape Colony, South Africa, the Government imported two diamond drills in 1880, and in order to distribute as widely as possible the benefits of trial borings, Government lends the tools and services of the foreman to private individuals, charging only actual expense without any profit.

The desirable-
ness of explora-
tion with
diamond drills
in Ontario.

In Ontario there has hitherto been no deep mining by the sinking of shafts, with perhaps the two exceptions of the Silver Inlet mine in Lake Superior and the Copper Cliff mine at Sudbury. To prove that ore is continuous in depth is of very great importance, especially in the case of narrow veins; and no doubt this can be done most expeditiously and cheaply with the aid of a diamond drill. There is a risk however that the cores may not show a fair average of vein matter, and the drill should therefore be put in charge of one having experience and knowledge. It might be advisable to purchase two drills, one of which could be operated in the eastern part of the Province, including the gold veins of Hastings and the Lake Wahnapiatae region, the iron deposits of Hastings, Peterborough, Frontenac and Lanark, and the nickel and copper deposits of the Sudbury district; while the other might be employed in the regions north and west of Lake Superior, including the iron ore deposits of the Mesabi range and the Mattawan and Atikokan rivers, and the gold veins of Lake of the Woods, Ruiny Lake and Lake Manitou.

XII.

MINING ACCIDENTS.

The following table gives particulars of the mining accidents which have been reported to the Bureau during the year 1893 : Accidents in 1893.

No.	Date.	Company or firm.	Mine.	Name of injured person.	Nature of injuries.	Cause of accident.
1	Jan. 9.	Dominion Mineral Co.	Bleazard	Emis Shrigley	Killed	Fell down shaft.
2	" 19.	H. H. Vivian & Co.	Murray	D. McNaughton	Severely burned on back and hips.	Fell backwards into pot of molten slag.
3	July 13.	Canadian Copper Co.	Copper Cliff {	H. Krookie	Not seriously injured	Blasting hot ore at roast beds.
4	Aug. 17.	Canadian Copper Co.	Copper Cliff	Albert Luckow	Not seriously injured	Blasting hot ore at roast beds.
5	Sep. 16.	Canadian Copper Co. . . .	Copper Cliff {	H. Johnson	Not seriously injured	Blasting hot ore at roast beds.
6	Oct. 16.	Canadian Copper Co.	Evans	H. Cowcaw	Not seriously injured	Blasting hot ore at roast beds.
7	" 27.	Canadian Copper Co.	Copper Cliff {	James Sheedy	Spine seriously injured	Caught by descending cage.
8	" 31.	Canadian Copper Co.	Copper Cliff {	Theophile Bouchard	Injuries resulting in death.	Premature explosion of duelin in hot roasted ore.
9	Nov. 9.	H. H. Vivian & Co.	Murray	George Tremblay	Slightly hurt	Caught in driving belt of ore crusher.
10	" 9.	H. H. Vivian & Co.	Murray	William McDonald. Right arm torn off.		
11	" 10.	H. H. Vivian & Co.	Murray	A. Philippek	Finger crushed	Loading car with ore.
12	Dec. 8.	H. H. Vivian & Co.	Murray	D. Tzosiak	Eyo cut	Splinter of rock knocked off by hammer.
13	" 21.	Canadian Copper Co.	Copper Cliff	John Owens	Shoulders burnt	Molten metal ejected by bessemerizing furnace.
				John McIntyre	Leg fractured	Fall of rock loosened by explosion.
				Alexander Bouchard	Injuries resulting in death.	Premature explosion of dualin in roast bed.

Killed, 3 ; injured, 13 ; total, 16.

General
results of acci-
dents.

Call for
greater vigi-
lance.

A leading
cause.

The number of accidents which have occurred during the year is out of proportion to the scale upon which actual mining operations were carried on. Thirteen accidents have taken place involving sixteen men, of whom one was killed instantly and two died within a few days from their injuries. Of the remainder, three or four were painfully hurt and at least one permanently disabled. In the other cases the injuries were comparatively slight, and the men were detained from their work for short periods only. All the casualties reported took place, it will be observed, in the copper-nickel mines of the Sudbury district, where by far the larger part of the mining work of last year was done. The causes of the accidents were in the main those which are common to mining in general, and which indeed seem inseparable from the industry in whatever country carried on, such as premature explosions, falls of rock and ore, contact with molten metal, etc.; yet it is clear that there is room for the exercise of increased vigilance on the part of managers and foremen, and of greater care on the part of workmen themselves if bodily injury and loss of life in our mines are to be reduced to a minimum. Want of experience may have had something to do with the number of accidents. Mining in Ontario presents, in some of its processes and details, features of an unusual kind, and the dangers attendant upon these have, it would seem, not yet been fully appreciated or guarded against by mining companies and their managers. A case in point is the use of explosives in beds of roasted ore, which has been a leading cause of accident. It must be said too that many of the men employed in the mines of the Province are unused to the work, for a large proportion of them have been bred to other pursuits, and mining is a business where ignorance often pays a terrible premium to experience. Not that the old miner is always the most careful man, for in this as in other occupations familiarity breeds contempt, and risks are sometimes run in a spirit of foolhardiness or indifference, or to save time and trouble, from which men unaccustomed to danger would shrink. It is the place of experience to point out the sources of danger, and of wisdom to avoid them. As the necessity for watchfulness and caution becomes more and more apparent, it may be hoped that fewer casualties will occur.

PREMATURE DISCHARGE OF EXPLOSIVES.

Breaking up
hot roasted ore
is

It has been said that the premature discharge of explosives used in breaking up roasted ore was one of the principal causes of accident. Almost one-third of the whole number, and two deaths out of the three, were due to this cause. As all familiar with the working of the copper-nickel mines of Sudbury know, the ore after being crushed by the breakers is piled in large heaps containing hundreds of tons over a few layers of dry pine cordwood with a view to being "roasted," the object being to expel the sulphur which it carries in large proportion. The wood on being fired ignites the sulphur, and the ore-heaps smoulder away, emitting their sulphurous fumes for many weeks, according to the size of the pile of ore. At the end of perhaps three months the greater part of the sulphur has been driven off, and the ore is then ready to be taken to the smelter. But in the roasting process a partial smelting or fusion takes place, and the ore is no longer in lumps but in the form of

larger or smaller masses which must be broken up before they are in condition for smelting. The use of explosives is generally necessary for this purpose, dualin being the agent chiefly employed. If the ore-heaps have been allowed to stand after burning until they become cool, there is no more danger in using explosives on the roast-beds than in the mine itself, although in any case it would be folly to entrust dualin to the hands of an inexperienced man. There is a temptation however when the smelters are in need of roasted ore to attack the piles while they are still hot, and it is evident that under such circumstances the use of explosives is attended with very much greater risk. To thrust a charge of dualin into a mass of ore almost at a red heat is to pay paying court to death. court to death, even if all the precautions are observed which are possible in such a case. This practice had obtained so great a hold, particularly in the roasting yards of the Canadian Copper Company, and had led to so many accidents, that it was deemed a proper subject of investigation by the Inspector of Mines.

THE CASE OF THEOPHILE BOUCHARD.

Previous to the explosion of the 27th of October, in which Theophile Bouchard received injuries resulting in his death on the 31st of the same month, several smaller accidents had occurred from this and other causes at the works of the Canadian Copper Company which, owing to ignorance of the law, were not reported to the Bureau at the time. On advice being received of Bouchard's death, and also of the previous accidents, the Inspector was instructed to make full enquiry into the causes and circumstances of these A special report by the Inspector of Mines. unfortunate occurrences with the object of recommending measures which might, if possible, avert such disasters in the future. The Inspector made a careful investigation on the spot and took the statements of all eye-witnesses and any who could throw light on the accidents or their cause. His report on the Bouchard fatality was as follows :

COPPER CLIFF MINE, Nov. 9, 1893.

The following statements were made by the respective parties named in connection with the accident which occurred on the 27th of October last, when Theophile Bouchard was injured, which resulted in his death. The General Manager of the Canadian Copper Company furnished me with the following statement in writing :

DEAR SIR,—Mr. Trist has the contract for one year to handle and roast all ore coming from mines to roast beds. He employs and makes the rate of wage for his own men : the company having no control over them ; nor have they ever had any in past contracts on roast beds. We have always ore enough on the beds to keep three furnaces at the present capacity on a continuous smelting. There is no necessity for working or blasting hot ore piles, as the daily supply of green ore from the mines to roast beds far exceeds the weight of roasted ore taken from the beds to be smelted, so that the tonnage of cold roasted ore should always be increasing, and not diminishing. At Mr. Trist's own request I have had to lessen the amount of green ore coming from mines, as he could not handle it quick enough. Yours respectfully,

The manager's statement.

JAS. McARTHUR, Gen. Mgr.

The roasting
contractor's
statement.

Robert Wm. Trist, examined, says : I am contractor for roasting the ore for the Canadian Copper Co's. smelters. I have held this contract since the 1st of May last, and it is to continue from that date for one year. I receive the ore in its raw state on board the cars on the trestle track along side the roast beds. I take the ore from the cars, put it on the roast beds, see that it is properly roasted, and then deliver it at the smelters as it may be required to keep the smelters supplied. I am paid by the ton for this work. I furnish every thing to do the work, such as labor, tools, explosives and all else except the wood which is delivered at the roast beds by the company for use. I had been working previously for two years in roasting ore at the Blezard mine, and had full charge for nine months. The whole surface or field on which the roast heaps here are placed would hold at least 70,000 tons, and about 50 ordinary beds can be placed on it at one time. I work at several ore beds at one time, and when built up I fire them. I sub-let the removing of all the ore from the roast heaps and taking it to the smelters. I exercise a supervision over this sub-let work to see that it is done safely and that no unroasted ore is sent to the smelters. Each man is paid so much per car. The men loading the cars have each done their own blasting after having been instructed how to do it. It was customary formerly to remove the ore from the roast heaps after it had cooled off, but more recently it has been removed when hot. This was necessary to properly mix the ore, there not being on hand a full supply of different kinds of ore for smelting properly. I furnish the explosives to be used by the men in blasting the ore on the roast heaps. I have a foreman, Thomas Smiles, whose duty it is to assist me in looking after this work, and he is especially to look after the roast ore part of the work. I take the green ore part on myself, and a general supervision over the whole work. In removing the ore from the roast heaps it is first loosened up and then taken by wheelbarrow to the cars. When the ore is compact or tight, it is necessary to use explosives to loosen it. In blasting when the ore is hot it is the custom to open a hole in the roast heap at least four inches in diameter and then cool it by pouring in water. The charge is wrapped in wet clay and a sack put round it before being inserted in the hole. The instructions to the men are to put in the explosive charge thus prepared and then to go away and not stop to tamp it. A long fuse is attached to the charge and lighted before it is put in the hole. The charge is pushed in the hole with a stick and the men get away. Another way of blasting hot ore is by making a hole in the ore bed about six inches in diameter and fill it with wet clay; then after cooling it with water, if necessary, push a bar of iron into the clay to make a hole of sufficient size to admit the stick of explosive. The fuse is lighted and the charge is put into the hole to explode, the charge being first prepared by covering it with a coating of wet clay. The man Bouchard who met with the accident was one of my best men and had been engaged in using explosives in hot ore for some four months. He had been previously accustomed to the use of dualin, and although acquainted with this kind of work was not one of the most careful of men, for I had occasion to check him about two weeks before the accident. He was not regularly at work at the place where the accident happened, but went over from another roast heap to assist the man at this blast who had not much experience in blasting. This I learned from him after his injury. I had myself been engaged in blasting hot ore at the Blezard mine for from three to four months, and I do not regard it as specially dangerous if done properly. Six other persons besides the deceased have been injured of late by explosions, including the man who was injured with Bouchard, but all quickly recovered. The last injured man will be around in a few days. I have positively instructed the men always to go away on inserting the charge and not to stop to tamp the hole. I was told by Bouchard that he remained a short time to tamp the hole when he

should have left the place ; but he remained and got hurt. I consider if my instructions had been carried out none of these accidents would have occurred. I never had any accidents occur in blasting at the Blezard mine in hot roast heaps.

Thomas Smiles, examined, says : I am foreman of the roast yard and am employed by Mr. Trist. My work is to look after the men, and to see that cars are loaded at the roast beds and unloaded at the smelter. I look after the men while engaged in loosening up the ore on the heaps and wheeling it out ; also to a certain extent over the blasting at the heaps. I always instruct new hands how to do the blasting, and go twice a day and deliver to the men the dualin or powder. I am employed by the day, but the men who load the cars are employed by contract, at one dollar per car. A car load averages about five and a half tons. The usual way of loosening up the ore on the heaps is by blasting. When the men are breaking loose the ore they require to put in about two blasts a day for each man. In instructing the men to blast hot ore I tell them to make a hole in the ore bed about four inches in diameter ; then take the stick of dualin and roll it in a cloth spread over with wet clay until about four inches in size ; then attach a fuse not less than two feet in length, and if the hole is very hot to light the fuse before putting in the charge. A two-foot fuse will enable a man to get half an acre away before the charge explodes. I also instruct the men to put wet clay in the bottom of the hole before inserting the charge. I have been engaged in this kind of work since 26th of May last. During this time there have been four mis-charges and seven men injured ; one of them fatally, the others slightly. In following my instructions I consider there is no special danger. The custom was until the beginning of this month to have any of the men handling ore to do blasting, but since the last accident only two men have been allowed to do this work. The supply of ore for the smelters was so limited that we could not wait for the heaps to cool off. This is the reason why we removed the ore in its heated state. I was not present when Bouchard was hurt, but was informed that it was an act of carelessness on his own part.

The foreman's statement.

George Tremblay, jr., laborer, examined, says : I have been working for Mr. Trist since October 7th up to the date of the accident, October 27th. I was working on roast bed 200 at the time of the accident. Bouchard came to help me, as I had been at his roast heap 195 and helped him. I made the hole in the heap for the charge, and Bouchard prepared the charge and put it in the hole. I think he lit the charge before he put it in. I was making the hole while Bouchard prepared the charge, and did not see him do it. I put wet clay in the hole but did not put in water. After the charge was put in the hole I threw in a handful of dirt and was in the act of putting in dirt and Bouchard was tamping it when it went off. We sometimes tamped the charge when handy to do so, and at other times did not do it. We more frequently tamped the holes than otherwise. I was not instructed to either tamp the charges or not to tamp them. I learned how to do this by working with other men, and these men tamped the holes ; do not know if Bouchard considered it dangerous or not. I have seen Bouchard tamp holes before. I often heard Bouchard say this was pretty risky work. I was never told how to do this by Mr. Trist or by Mr. Smiles.

Statements by employés.

George Tremblay, jr.

George Tremblay, examined, says : I am employed by Mr. Trist to work on the roast heaps at the Copper Cliff. I had finished my day's work when the accident occurred in which Bouchard was injured, on 27th October. I have been working for the past two months, taking the ore from the roast beds. I have put a few charges myself in hot ore, but usually I have had someone else put them in because I was afraid to do it. I was never told

George Tremblay, and

how to do this kind of blasting, except by the men who were with me. I have regarded the blasting in hot ore as dangerous. After Bouchard was hurt I went from my house and got him and brought him home. I never heard Bouchard say how the accident happened, nor did I ever ask him. Bouchard lived four days after the accident, and I attended him. He was my brother-in-law and lived with me at the time of the accident and death. I have worked with Bouchard on the same beds, and he has often put in charges for me. When the hole was very hot it was usual to go right away after the charge was put in, but when not too hot the holes were tamped. I have tamped holes.

Albert
Luckow.

Albert Luckow, examined, says: I have been working for the Canadian Copper Company for about three years, and for the year past on the roast beds. I have had experience in blasting both cold and hot ores. I am hired by Mr. Trist, and I do my work by contract under him in removing ore from the roast heaps to the cars. The only way to break up the ore on the heaps is by blasting it. About two blasts per day are necessary for each man, and all or most of the men did their own blasting. It has been the custom to instruct the men how to do this work. I have been told how to do it both by Trist and Smiles, and also under the former contractor for whom I worked last summer. I do not regard blasting in hot ore as much more hazardous than in cold ore, provided due care is exercised. I blasted in cold ore only last summer. I only know of one accident last summer, and that was by Mr. Morrell, the contractor himself, in cold ore. A considerable quantity of hot ore was blasted last summer (1892), and every man did his own blasting. About two months ago I met with a slight accident by blasting in hot ore. This occurred by my failing to wrap the dualin up in wet clay on a rag, although I had put wet clay in the hole and pushed in a bar to make a hole for the charge—a common way of blasting. I was tamping the hole when the charge exploded. If the hole is tamped the charge will break up much more ore than by leaving it untamped. I do not know if any instructions were ever given forbidding men when blasting to tamp the holes, but they usually exercise their own judgment in doing this. I always tamp the holes. I do not know anything about the accident which occurred on 27th October, when Bouchard was injured. I heard of some other accidents by blasting in hot ore this summer, but do not know about them. I understand that two careful men of experience are now to do all this blasting in all the roast heaps, which I think is a good thing for safety.

The Inspector's
conclusion—
1904.

The Inspector stated the conclusions he had arrived at in the following terms. "It is certain that Theophile Bouchard came to his death by an accident which occurred when blasting in hot ore. After inserting the charge he remained to tamp the hole where the accident happened, contrary to the instructions of Trist, the contractor; nor could Bouchard have been ignorant of the imminent danger of such a practice, as he had been engaged at this kind of work for four months. He had also been checked by his employer, but a couple of weeks before, for carelessness. I consider that at the time of the accident he did not exercise such due precaution in blasting as he might have done to avert it. From the information obtained, I am satisfied that the practice of tamping holes after charges were put in had become too common among the men. I have carefully examined the whole system of blasting in hot ore, and I regard it as a practice attended with too great danger to be allowed. A recent change has been made on the roast yard at the Copper

Cliff, viz., in not permitting every man working on the roast beds to do his own blasting, as the custom has formerly been, but by limiting it now to two careful men of experience. This no doubt will greatly lessen the risk of accidents, but will not entirely remove it."

A coroner's inquest was held on the death of Bouchard by Dr. R. B. Struthers of Sudbury on 1st November. The jury returned the following verdict: Coroner's inquest on the case.

That Theophile Bouchard came to his death as the result of an accident brought about by his own carelessness. And we strongly recommend that such means as are necessary be taken to get and keep on hand a sufficient stock of ore so that men will not have to work and handle hot ore. In the meantime we recommend that one man only, and he an experienced one, be allowed to fire on holes in hot roast beds.

THE CASE OF ALEXANDER BOUCHARD.

The fatal accident to Theophile Bouchard was followed on 21st December by another from the same cause, by which Alexander Bouchard was mortally wounded, though he did not actually die until 3rd January, 1894. The circumstances attending the second fatality were pretty much the same as those of the first, with the exception that the ore in which the deceased was working is described as being "not very hot." Previous to the time of the first accident it appears to have been the custom to allow men working on the heaps of roasted ore to handle their own explosives. At the Canadian Copper Company's works the breaking up and delivery of the roasted ore is carried on by a contractor, who employs and directs the workmen, the company disclaiming any responsibility in connection with this department of the work. On the 3rd of November, moved thereto by the recommendation of the jury at the inquest held on the body of Theophile Bouchard, the contractor (Mr. R. W. Trist), entrusted the duty of using explosives on the ore heaps solely to one man experienced in this branch of the work, and at the same time forbade the workmen to use the explosives themselves. The men however were paid by the piece, and being anxious to get on with their work, whenever they found it inconvenient to wait for the services of the man appointed to do the blasting, they did not hesitate to make use of the powder themselves if they could get it. The man, Paul Rioux, placed in charge of the exploding, seems to have had somewhat lax ideas about the way in which his instructions were to be carried out, for on several occasions he gave powder to the men for their own use. On the day of the accident Rioux was laid off work with a frozen foot. This was known to Thomas Smiles, the foreman at the roast yards, whose duty it was in the blaster's absence to attend to this dangerous work himself. He made no effort to do this, or to have anyone put in Rioux's place; but instead authorized the men to get the key of the powder-house and help themselves. This the men, unwilling to be idle, were in no way reluctant to do, and they procured the necessary dynamite to loosen the ore and proceeded to make use of it. Napoleon Sauve, Bouchard's neighbor on the ore heap, testified that after deceased had made a hole in the ore in which to place the cartridge, he pushed the latter home with a broom Another fatal occurrence from the same cause.

An instruction disregarded.

and the fatal
consequence.

handle, when the charge at once exploded. Bouchard received terribly severe injuries, chiefly about the face and shoulders, the ball of one eye being completely destroyed, and the other nearly so. Blood poisoning set in at the end of a week, and death took place on the 3rd of January.

A thorough
investigation
ordered.

Owing to this second fatality following so closely upon the first, it was determined to make it the subject of a thorough investigation, and accordingly instructions were given to stipendiary magistrate Doran of North Bay to conduct a coroner's inquest on the body. Mr. J. H. Metcalf, Pembroke, Crown Attorney for the county of Renfrew, was detailed to assist in prosecuting the inquiry. A jury of twenty-two residents of Sudbury was impanelled, with Stephen Fournier as foreman, and the circumstances of the accident as given briefly above were fully brought out. The verdict of the jury was as follows:

The verdict.

That Alexander Bouchard did come to his death accidentally from his own careless handling of explosives. We also wish to strongly recommend that mining companies should not be released from the responsibility for the safety of their men, but should supervise their works in all its departments where men are exposed to danger, and not allow such lack of care as was shown by the contractor and his foreman on the roast beds at Copper Cliff, which may possibly have led to the death of deceased Alexander Bouchard.

Laxity of
supervision.

The jury, while satisfied that primarily Bouchard was responsible for his own death, evidently felt that there was a laxity in the supervision and management of this department of the company's operations which was inconsistent with a proper regard for the security of the men employed in it. Where blasting operations are carried on above ground, and in the light of day, it ought not to be difficult to surround the use of explosives with safeguards which will almost entirely do away with the possibility of such disasters. If a mining company can rid itself of responsibility for the safety of workmen by letting out to a contractor the work on which they are employed, such responsibility does not cease to exist, but devolves upon the contractor; and it is therefore the bounden duty of the latter to take every possible precaution, even if need be against the inclination of the men themselves, to prevent injury and loss of life. In this case the coroner's jury were of opinion that the contractor had not taken such precautions, and that his foreman, Smiles, showed great carelessness in the matter. The latter was indeed reprehensibly negligent, for although, to use his own words, he was fully aware that in the absence of Rioux he "was responsible for the powder and blasting," and that "none of these men should have been allowed to get powder from the powder-house that day," he nevertheless, according to the testimony of the workmen, expressly instructed them to get the powder for themselves and do their own blasting. While such gross and indeed almost criminal carelessness is permitted by mining companies and mining managers in the handling of dangerous explosives, we can expect nothing but a repetition of fatalities of this kind. Mining is at best a more or less hazardous occupation, and there are causes of accident which the exercise of the utmost caution and vigilance can hardly eliminate; but where a few simple rules rigidly enforced would almost wholly remove danger, as in this case, it is a pity that such safeguards are not adopted.

REMEDIAL MEASURES PROVIDED.

The Inspector's investigation of the Theophile Bouchard fatality having shown that the practice of blasting in hot ore was a dangerous one and ought to be discontinued, formal notice was served by him upon the general manager of the Canadian Copper Company and the contractor for roasting that company's ore, in the following terms:

Sir,—An investigation into the causes and circumstances of recent accidents at the mines and works of the Canadian Copper Company at Copper Cliff having convinced me that the blasting of hot ore on roast heaps is carried on at the risk of life or bodily injury to the persons employed thereat. I hereby notify you and any contractors or others employed upon or about the mines and works of said company under your authority, by virtue of the power conferred upon me by the sixty-fifth section of The Mines Act 1892, that such blasting of hot ores is a dangerous practice within the meaning of the Act, and to require that it be discontinued forthwith upon receipt by you of this letter.

Similar notice was given to the managers of H. H. Vivian and Company and the Dominion Mineral Company. The prohibition of blasting in hot ore was made permanent by a clause in the Act relating to Mines and Mining Lands passed by the Legislature in the session of 1894. Section 10 of this Act amends The Mines Act 1892 by adding to Rule 2, section 74 thereof, the following clause: "No gunpowder, dualin, dynamite or other explosive shall be used to blast or break up ore in roast heaps where by reason of the heated condition of such ore or otherwise there is any danger or risk of premature explosion of the charge." The said section was further amended by inserting in Rule 21 after the word "mine" in the sixth line thereof the words "or contractor or foreman employed in or about such mine." The effect of the latter amendment is to make a contractor or foreman liable in case of an offence against the Mines Act as well as an owner or agent, unless he can prove that he has taken all reasonable means to enforce the Rules provided by the Act and to prevent non compliance therewith.

Notice to dis-
continue prac-
tice of blast-
ing hot ore

Provision
against the
practice by
legislation.

OTHER CAUSES OF ACCIDENTS.

The Inspector's inquiry and report on the case of Theophile Bouchard also covered the accidents to James Sheedy and William McDonald, numbered 6 and 8 respectively in the table given above, both of which, though not fatal, were of a serious character.

On the 16th of October Sheedy, who was employed in the underground workings of the Copper Cliff mine, wishing to descend from the third to the fifth level, leaned forward into the shaft for the purpose of pulling up a gate in order to clear the way for the cage. While in the act of doing this, the cage descended and doubled him up, inflicting injuries upon his spine. He was sent to the General Hospital at Toronto for treatment, where he recovered, the company paying all his expenses. It was clearly shown, and indeed admitted by the injured man himself, that the accident was entirely due to his own want of care. A hook was provided for the purpose of raising the gate in question, but it was a few feet away from its usual position at the

Accident in a
shaft.

Machinery
accident.

time, and rather than look for it Sheedy leaned forward and attempted to raise the gate by hand. The engineer was positive he received the usual signal of two bells to lower the cage, but it could not be ascertained who gave it.

On the 31st of October William McDonald, 17 years old, had his right arm torn off in attempting to throw off the belt of the ore-crusher screen in the Copper Cliff rock house while the machine was in motion. This painful accident was due to his own lack of prudence.

Killed by fall-
ing down a
shaft at the
Dominion
Mineral Co.'s
mine.

Ennis Shrigley lost his life at 5.30 a.m. on the 9th of January, by falling down No. 4 shaft of the Dominion Mineral Company's mine at Blezard. The circumstances of the accident were as follows: This man, who was about 45 years of age, was employed at the head house emptying buckets which were being hoisted up through the shaft, the dimensions of which were 3 feet 6 inches long by 2 feet $5\frac{1}{2}$ inches wide. With two others he was warming himself at a fire about three feet from the shaft opening. He stepped away from the fire to get some wood, and the others hearing a slight noise turned and saw him fall down the shaft head first. The opening is fenced at the front and back, but not at the sides, where the aperture is only large enough to admit of a car being run forward to receive the contents of the buckets. The man was instantly killed. It is supposed that he was either dazed by the cold, the weather being very severe, or was taken in a fit. An electric light was burning within two feet of the hole at the time. The coroner was advised, but declined to hold an inquest unless requested to do so by the company or some relative of the deceased. As such request was not made, no inquest was held.

Accidents of a
minor charac-
ter.

The other accidents were of a minor character, the most serious being those to D. McNaughton and John McIntyre, both of whom were injured at the Murray mine owned by H. H. Vivian and Company. The latter had his leg broken by a fall of rock. The former while walking backwards and wheeling a pot of molten slag and metal had the misfortune to sit down in a similar pot of slag and metal carelessly left in the way by a fellow workman. He was painfully burned, but not permanently injured.

CORONERS' INQUESTS.

Independence
of officers
holding in-
quests.

In connection with the investigation of mining accidents, it was felt that there were grave objections to the practice of allowing coroners to conduct inquests in the case of persons who had been in the employ of companies or firms by whom the coroner was himself either directly or indirectly employed as medical adviser or interested as a stockholder. It is a common arrangement with mining and other companies to engage a physician at a stated figure per man to attend upon their employes, such sum being usually deducted from the men's wages. It is obvious that when a fatal accident occurs in the operations of such a company a coroner who is also the company's physician is not in a position to conduct an impartial investigation. It is no reflection upon the integrity of gentlemen so situated to say that their independence would be open to serious question, and that the friends of a man

who met his death by accident would be inclined to view the actions and regard the motives of such a coroner with greater suspicion than in the case of one not connected by ties of interest with either side. The preliminary investigation conducted under the direction of a coroner is usually of a grave and important character, and it ought not to be open to attack on the ground of the real or alleged partiality of the coroner. Having these considerations in view, representations on the subject were made by the Bureau to the Attorney-General's Department, and in the session of 1894 provision was made in the Act respecting certain Duties of Coroners (57 Vict. chap. 31, section 4) by which a coroner under the circumstances described above is declared incompetent to act. The clause enacted is as follows :

Statutory
provision of
incompetency
in certain
cases.

It shall not be lawful for a coroner to conduct an inquest in any case where loss of life has been caused at or on railroads, mines or other works whereof he is owner or part owner, either as shareholder or otherwise, nor in any like case at or on works where he may be employed as medical attendant by the owner or owners thereof, or by any agreement or understanding direct or indirect with the employes at or on such works.

T. W. G.

XIII

KINGSTON SCHOOL OF MINING.

The Kingston School of Mining and Agriculture has been organized under an Act of the Legislature of Ontario. Its objects as stated in the calendar for 1893-4 are as follows :

Objects of the School.

1. To give a complete scientific education of both a theoretical and practical character to young men studying for metallurgists or mining engineers.
2. To give practical instruction to prospectors, mine foremen and others interested in the discovery and winning of minerals.
3. To lead prospecting excursions of the students as well as of those more directly interested in the development of mineral lands.
4. And to provide theoretical and practical instruction in subjects pertaining to modern agriculture, such as dairying, veterinary science and the chemistry, botany and zoology of the farm.

Its organization.

The School has been founded on a joint stock basis, being authorized to issue stock to the amount of \$100,000 ; but in addition it receives a grant of \$5,000 yearly from the Province of Ontario, and may also receive aid from local or county municipalities. The management is in the hands of a Board of Governors, composed of the following gentlemen :

J. B. Carruthers, Esq., Chairman	Kingston.
Hiram A. Calvin, Esq., M. P., Vice-Chairman	Kingston.
G. M. Grant, LL.D., E.D.	Kingston.
E. W. Rathbun, Esq.	Deseronto.
James Swift, Esq.	Kingston.
G. M. Macdonnell, Esq., B.A., Q.C.	Kingston.
E. J. B. Pense, Esq.	Kingston.
William Harty, Esq., M.P.P.	Kingston.
James S. Haydon, Esq.	Centreville.
M. H. Folger, Esq.	Kingston.
J. L. Whiting, Esq.	Kingston.
George Y. Chown, Esq.	Kingston.

The mining department opened.

Its scheme.

The Mining Department was opened on the 9th of October last year, but arrangements have not yet been fully completed for opening the Agricultural Department. The scheme of the School in relation to the mining courses will be readily understood from the following provisions, adopted by the Board of Governors previous to and during the first session :

I. The degree of Mining Engineer (M. E.) will be conferred on those who take the specified course and pass the required examination.

II. Unmatriculated students may take any classes and examinations that they wish, as it is desired to give opportunities to persons who do not intend to follow engineering as a profession to receive the benefit of courses likely to be useful in common life.

III. Special courses of instruction to mine foremen, assayers, prospectors and mining men generally, continuing for eight weeks.

iv. Evening lectures for persons desirous of learning something of the course, but unable to attend during the day.

v. Short courses, accompanied with experiments, specimens, diagrams, etc., by one of the staff in outside localities.

vi. A summer School of Science for Public and High School teachers and others, continuing in session for five weeks. Classes of the first session.

The following memorandum of classes in the Mining Department of the School for the session of 1893-4 has been furnished me through the kindness of Rev. Principal Grant of Queen's University, a member of the Board of Governors:

i. *Number of Students:*

		Fees paid.
(a) Number of regular students	102	\$1,506 34
(b) Number taking short courses	47	176 00
Total		1,682 34

ii. *Classes taken by the Regular Students:*

	Professor or Lecturer.	Number in Class.
Junior Chemistry	Dr. Goodwin	48
Senior Chemistry		43
Analytical Chemistry (Elementary)	Dr. Wood	29
Junior Practical Chemistry		39
Organic Chemistry		33
Quantitative Analysis	Mr. Walker	4
Qualitative Analysis		9
General Practical Chemistry		2
Honors, Chemistry of Fuel, Ores, Fluxes, etc.	Dr. Goodwin	12
“ Organic Chemistry		8
“ Crystallography		9
“ Physiological and Pathological Chem.		3
“ Quantitative Analysis		3
Mineralogy, 1st year	Mr. Nicol	14
Blowpipe Analysis		15
Honors, Mineralogy, 2nd year		4
“ Mineralogy, 3rd year, Descriptive Mineralogy		2
“ Mineralogy, Determinative Mineralogy		1
“ “ Blowpipe Analysis		1
“ Qualitative Analysis		5
“ Assaying		4
Geology, 1st year pass; Field work, Museum work and General Geology	Mr. Miller	12
1st Honor, Petrography, Physical Geography, Palaeontology, Dynamic Geology, etc., Laboratory work, Museum work and Field work		9
2nd Honor, Advanced Geology—Historical, etc., Economic Geology—Ore deposits, etc., Petrography, Geology of Canada, Museum work, Laboratory work	Mr. Miller	5
Drawing	Mr. Mason	6

iii. *Classes taken by the Short Course Men:*

Any of the above classes for which the men were fitted; in addition, special instructions by the above-mentioned members of the staff; also, courses of lectures, illustrated by diagrams, specimens and experiments, by W. Hamilton Merritt, M. E., on the application of the

principles of chemistry, mechanics, mineralogy and geology to the discovery and winning of valuable minerals, and to the usual methods and machinery in vogue to open up the deposits and exploit and prepare the ore.

Courses for
students.

It will be observed that the students are comprised in three distinct classes, viz.: (1) Mining students proper, who take the four years course; (2) students who take the eight weeks course; and (3) special students.

Six students are taking the full course of Mining Engineering, having entered upon it at the opening of the session in October.

The eight weeks course did not open until the 9th of January, when a class of seven men was formed, who took lectures in chemistry, mineralogy and blowpiping, geology and petrography, assaying, drawing, prospecting and mining. Class-room attendance occupied 300 hours in the 48 days of the course, or an average of $6\frac{1}{4}$ hours per day. The work was largely of a practical character, and the students entered into it very heartily. I had the honor of visiting the school towards the close of the first term, at the invitation of Principal Grant, and two days were spent in the several class-rooms. I cannot speak too highly of the spirit which prevailed in the school on the part alike of professors and students; and I have no doubt that this departure, which is a novel one in the educational institutions of Ontario, will in time be productive of very beneficial results on our mining industry.

The evening class had a registered attendance of 23, to whom lectures were given during the course, illustrated by experiments, diagrams and specimens.

Equipment of
the School.

The equipment of the School is modest as yet. Besides accommodation for 24 blowpipe students, there are three wind furnaces, one large muffle furnace, one charcoal furnace, one portable coke furnace and three gas furnaces, the object being to teach assaying with all kinds of fuel.

For the present the School is housed in the John Carruthers Science Hall—one of the solid buildings of Queen's University—but it is probable that ere long it will have a hall of its own, with a complete outfit for a well established School of Mines.

Outside
classes.

At the close of the short course in March of this year Mr. W. H. Merritt, one of the lecturers, conducted a special class at the village of Marmora. It was on the plan of the New Zealand schools, and the course extended over a period of two weeks. Seventeen students attended the lectures there.

REPORT OF THE INSPECTOR OF MINES.

TO THE DIRECTOR OF THE BUREAU OF MINES:

SIR,—I have the honor to transmit to you my fourth annual report on the Inspection of Mines, being for the year 1893.

The brevity of the report is in part due to the fact that a very considerable number of the mines have been lying idle during the year, notably those of iron, silver and phosphates. A large number of these mines have been worked extensively in former years, and, hoping along the line of our interests, we may anticipate a renewal of operations at not a distant date.

Inactivity
owing to the
financial de-
pression.

A number of causes have recently arisen which have combined to prevent an extensive development of our mines. Although Canada has been exempted in some degree from the heavy financial depression resting upon other countries, yet serious effects have been realized in this Province by reason of the capital which would otherwise have been expended in mining interests having been withheld, and especially is this the case when largely dependent upon the neighboring Republic for the capital required to push forward the work in the mines. The general suspension of business in many quarters in that country, and the repeal of the Sherman Act (which in effect shut down the silver mines in all the silver-bearing States), could not fail to have a depressing influence upon our mines. With the revival of silver mining in Colorado and other important producing centres, we may reasonably anticipate that the hitherto large yielding properties in the Thunder Bay district will again be vigorously worked, and that many of the encouraging discoveries of silver and other mineral deposits now lying undeveloped will be opened up.

Since the entire suspension of silver mining, much more attention has been given to gold mining in Ontario, which has an encouraging outlook.

I have made no report upon the gold and copper mines of the Province, as you have had the opportunity of personally examining them, and will no doubt give a full description of their present condition.

SILVER.

A special correspondent of the New York Engineering and Mining Journal in October says of Rabbit Mountain mine: "This mine, under option to a Duluth company, has been closed after shipping a car load of picked ore, the result of the season's work. It was the last of the Thunder Bay mines to remain in operation."

Rabbit Mountain mine.

Mr. Hille, M.E., of Port Arthur, states: "Last year a number of gold veins were discovered not more than 50 miles west of Port Arthur which promise well. The veins vary in width from 2½ feet up to over 40 feet, and the ore assays from \$10 to \$50 in gold and silver. The ore is not free milling, but is through the occurrence of a large percentage of copper a very good material for Dr. Hoepgaer's process."

New discoveries west of Port Arthur

Ogema mine.

The Ogema mine was sold at public sale at Port Arthur, August 15th. The affairs of the company will be wound up on account of dissension among the stockholders. The mine, which has not been worked for some time, was bought by J. F. Ruttan of Port Arthur for \$925.

COPPER AND NICKEL.

Canadian
Copper
Company.

Work was being actively carried on in Copper Cliff mine at the date of my visit in June, under the charge of the late Captain James. Twenty men were employed on the day and night shifts, and about seventy-five tons of ore lifted daily. The principal workings were in the fifth, sixth and seventh levels, for a description of which see former report. Especially in the seventh, the lowest level in the mine, an excellent body of ore was exposed, and appearances would indicate its continuance to a much greater depth. The workings at this point, nearly 500 feet vertical depth from the surface, are the lowest reached in any of the mines in the locality. The excellent showings at the depth named should strengthen the conviction of the existence of large bodies of nickel ore at great depths, which if demonstrated must necessarily enhance the value of nickel properties throughout the Sudbury district.

Copper
Cliff mine.

Progress of
mining opera-
tions.

In view of the existence of this large body of ore and its probable continuance to much greater depth, as well as the long distance of the drifts to be run in from the incline hoist track, it has been determined by the management of the company to sink a vertical shaft directly upon the ore.

The work in the mine was being conducted with the usual care and safety. I directed the attention of the captain to the large original opening at the surface which required fencing, and he had this done at once.

In November this mine was under the care of Captain Davis, who had but recently assumed control. He accompanied me through all the parts of the mine then being worked. The usual force of men was employed both underground and above ground. The showing of fine bodies of ore in the mine was not less encouraging than at the time of my former visit, especially in the deepest workings. A large quantity of ore was being taken out and prepared in the usual way for the roast yard in the rock house, which is a convenient and substantial structure. The work, both in the mine and in preparing the ore for roasting, was being managed with apparent economy, and due care was paid to the safety of the workmen. The air receiver at the compressor, which was dangerously exposed at my former visit and to which I called the attention of the master mechanic, had been neatly and substantially protected by a sheath.

Mr. James McArthur, who formerly had charge of the smelting department, has now the general management for the company. In a recent communication he states: "As usual the cold weather in December compelled the stoppage of ore raising, and none has been produced since the middle of that month. Outside of this there is nothing new to report."

Accident.

An accident occurred in the rock house in this mine on the 31st of October, when William McDonald, a young man, had his right arm torn off near the shoulder by a belt. He was imprudently pulling it off the pulleys when part of the machinery was in rapid motion. The particulars of this accident

are given in a special report on accidents to the Honorable Commissioner of Crown Lands.

The smelters had been standing idle for some time, but started up in May, and in the latter part of June about seventy-five men were employed. They were running to their usual capacity and doing efficient work. One of the engines required railing put up to prevent accidents when passing it, which was done. In November they were also thoroughly manned, in excellent running condition and doing their full quota of work, averaging about 200 tons of ore daily. A large stock of wood was on hand. Nothing new to report by addition or change to the plant except the following, as stated in a recent note from the manager: "An enclosed overhead passage-way is running from No. 1 furnace to the outer slag dump. Our granulated slag is conveyed through this passage, which was built by the company for the comfort of the men as a protection against the weather."

The smelting
furnaces.

The ores from the three mines of the Canadian Copper Company, the Stobie, Evans and Copper Cliff, are taken to the large roast yard near the smelters for calcining. The yard is of sufficient size to hold eighty or ninety thousand tons of ore, and from fifty to sixty roast heaps containing fifteen or eighteen hundred tons each may be built upon it. These huge piles of ore require ten weeks or longer to burn, and a considerable period of time to cool off. The ore is roasted by contract, and the general manager disclaims control over this part of the work.

The roasting
yard.

During the season a departure from the usual custom of allowing the roast heaps to cool off before being removed had been adopted by the contractor, by breaking them up in their heated state with the use of explosives. This practice resulted in a series of accidents caused by unexpected or premature explosions, two of which proved fatal.

Accidents due
to the practice
of blasting hot
ore.

In pursuance of instructions, I made a careful examination as to the causes of these accidents, except the last, and submitted a special report thereon to the Honorable Commissioner of Crown Lands.

I regarded the practice of blasting in hot ore as dangerous and likely to cause personal injury and loss of life, within the meaning of the Mines Act, and accordingly gave notice to discontinue it.

Although believing that this practice was not followed at other roast yards, yet as a precaution against and for the purpose of preventing it, I issued similar notices to the managers of all companies at whose works ores were being roasted, which precaution I am informed met with their entire approval.

In November about fifty-six thousand tons of ore were on the roast beds, and from sixteen to eighteen thousand tons of green ore were on hand.

This pioneer company has produced up to December 1st 300,000 tons of ore and 40,500 tons of matte—equivalent to about 6,500 tons of copper and 5,600 tons of nickel.

Late in June but little work was being done in the Stobie mine. The Stobie mine walls were being trimmed and some parts of the interior fitted up under Captain John M. Jones, who had formerly been in charge of Copper Cliff mine. The large open pit was partially filled with water, but could be quickly emptied when necessary to resume lifting ore.

The new rock house and machinery.

The new rock house had been completed. It is a substantial structure, 40 by 50 feet and 70 feet in height, and superior to any other in the Province. It is supplied with a powerful Blake crusher capable of breaking 125 tons of rock in ten hours, and has space provided on the floor for placing three others of equal capacity when required. The dump floor was to be covered with three-quarters inch steel plate, which was on hand and ready to be put in place. The whole is admirably fitted up with screens, chutes, etc., and a track underneath where the cars may receive the ore from the bins when sorted, crushed and screened, to convey it to the roast yard at Copper Cliff. In the building is placed a 30 h. p. engine to drive the crusher, screens, etc., the steam being supplied from the boilers placed in the adjoining engine house. This building, situated fifty feet east of the rock house, is also a fine structure in which are placed two boilers, each of 80 h. p. capacity, and a powerful engine to drive the large Ingersoll air compressor, capable of running seven three-inch drills. There are also two drums for hoisting ore, with engines attached of 40 h. p. each, capable of lifting with skip not less than four tons at each hoist. There is a large heater for heating the water before going into the boilers, and also an air receiver of large capacity.

A good incline skip track was being constructed from the dumping floor of the rock house to the open pit. From the drums in the engine house the strong steel cables pass over pulleys and reach the upper apartment of the rock house and connect with the skips, having a capacity of two tons each.

The machinery had not yet been started, but was put up in a thoroughly workmanlike manner and of the most approved class. The whole outfit presents a fine appearance, and the large outlay in the new plant has been warranted by the exposure of extensive bodies of ore. This mine, from present showings, may be regarded as one of the most valuable mining properties owned by the company.

Evans mine.

The last of June I spent considerable time in going through the Evans mine, accompanied by Captain Alfred James, and I found the workings in good condition. About fifty men were then employed in and about the mine. Since my previous inspection in September considerable work had been done in the first level, or large open pit, from which about 1,000 tons of ore had been lifted. An equal quantity had been taken from the second level, and a winze had been opened between the first and second levels. Stopes had also been made in the third level, from which about 1,000 tons of ore had been mined. In the fourth level considerable stoping had been done both north and south of the shaft, and some 2,000 tons of ore secured. A winze was opened connecting the third and fourth levels. On the fifth and lowest level a sump has been sunk eight by twenty-six feet and nine feet deep, to receive the accumulating water, at which point the pump is placed as described in the former report. Both north and south of the shaft limited stopes have been made and about 800 tons of ore removed. The total depth of the workings is 275 feet from the surface, and with a good showing of mineral. For process of treating the ore see former reports.

Extent of the workings.

In November I again inspected the mine and found it in a safe state, with the usual force of men employed, under the direction of Captain H. Davis,

who has but recently taken the place of the late Captain James, and who has had thirty-five years' experience in the management of mines. I directed the attention of the captain to the exposed condition of the large open pit adjoining the rock house, and the following day he had it securely fenced.

An accident occurred on the morning of October 23rd in the shaft of this mine, at the third level. James Sheedy, a young workman, was attempting to lift the gate by hand, when the cage descended on him and seriously injured his back. A hook was provided and generally used for raising the gate, and had Sheedy taken advantage of this the accident would have been averted. Due care was taken of the injured man, and after the lapse of a few days, upon the advice of the attending physician, he was sent to the General Hospital at Toronto. Three or four weeks after the accident the resident physician informed me that he was slowly improving, and that in time he would most likely entirely recover from the injury. Sheedy spoke in terms of highest praise of the consideration shown to him by the company, and also informed me that all his expenses were being defrayed by them. He stated that the accident happened through want of forethought on his own part.

I visited the Blezard mine in June. The mining was being done in the open pit, in which were twenty-five men on the day and night shifts, and about eighty-five tons of good ore were taken out daily. The main portion of the roof had been removed and all the pillars, excepting the shaft pillar, had been thrown down. Seven or eight thousand tons of mixed rock and ore were lying on the floor of the opening. The hoisting was being done by steam derrick. The standing walls had been well trimmed, and the work was being carried on with safety. It was intended during the summer to take out this large mass of material, and also to take down the shaft pillar. No work was being done below this point, and the shaft was covered over. Dominion
Mineral
Company.

The timbering in shaft No. 4 had been completed and a good cage put in for lifting ore. No additional sinking had been done. A cross-cut had been made in the west drift, about sixteen feet from the shaft, and a stope made from which a small quantity of ore had been taken. Blezard mine.

The smelter was treating from 120 to 140 tons daily, varying with the different classes of ores; twenty-eight men were employed in this department. About 14,000 tons of ore, roasted, or in process of roasting, were on hand, 3,000 tons of which had been brought from the Worthington mine. The magazine is situated half a mile distant from the mine. About 7,000 cords of wood were in the yards. Smelting
operations.

The work was being carried on with a total force of 140 men, economically and with safety, both in the mining and smelting departments.

The manager, Mr. Ian Cameron, rigidly enforces the sanitary rules, and no epidemic prevailed at the place.

In November, when I again visited this location, both mine and smelter were closed down, but I am informed by a recent letter that both will be reopened during the coming spring.

The Worthington mine was discovered at the time of the construction of the Canadian Pacific Railway, by the gentleman whose name it bears, Mr. Worthington
mine.

James Worthington, who was then a contractor for building a portion of the railroad stretching by this property. He still continues to be one of the large shareholders and is a director of the company now owning and operating it.

Extent of the workings.

At the date of my inspection, at the end of June, Mr. Cameron, the manager, accompanied me to the mine, where a force of thirty-five men was employed under the direction of Captain R. McBride, chiefly engaged in development work and taking out about 15 tons of ore per diem on the day and night shifts.

Shaft No. 1 was sunk to the depth of 140 feet, and from the surface neatly timbered down fifteen feet to the solid formation. The first level, at fifty feet from the landing, was driven in thirty feet west, and a small stope made. Levels are driven in at 110 feet from the surface, both east and west, the former to the distance of twenty-one feet and a communication made with shaft No. 2, thus affording excellent ventilation. Shaft No. 2 was not being used, the ore being lifted in shaft No. 1.

In the west drift, at a distance of forty feet from the shaft, a cross cut was being made at this date. Work was also being done at the bottom of the shaft, thirty feet below these levels, sinking in an excellent body of ore. A ladder way was being put up, which was partly walled off from the shaft, with rests twenty feet apart. Steam power was used for hoisting the buckets. A good cage hoist would be provided as soon as stoping was done to any considerable extent.

Machinery

The machinery consists of two boilers, a double drum hoist and an engine to drive the large Blake crusher, capable of breaking 100 tons of rock in ten hours.

and buildings.

The buildings are a shaft house twenty by thirty feet, with adjoining rock house thirty by thirty-two feet, floored with steel plates; engine house thirty by forty feet; blacksmith shop and stabling, boarding house and office and six dwellings. The magazine is situated half a mile from the mine.

The ore shipped to Blezard mine.

After the ore is sorted and crushed it is loaded on cars and taken via the Canadian Pacific Railway to the roast yard at the Blezard mine, a distance of thirty miles, and prepared for the smelter. Smelting works, it is expected, will be constructed at this mine at a not distant date. A large percentage of the ore removed continues to be of high grade. Work was suspended at the mine for some time during the latter part of the summer, but was recommenced in November with a considerable force of men and has since been vigorously carried on.

A communication from the captain of the mine of recent date states that a third level has been run in a short distance, and also that the principal place of working was in the raising chute stope connecting shafts Nos. 1 and 2, from which place they were getting at present the bulk of the ore.

H. H. Vivian & Co.

My first visit this year to the Murray mine was in the latter part of June, and the management was the same as the previous year. Work had been suspended before the close of 1892, but was recommenced in April last. Sixty men were employed in the mining department under Captain Richards,—thirty-one on underground work and twenty-nine above ground.

Three improved Ingersoll-Sargent drills had been added, and five were in use in the mine. About the usual quantity of ore was being mined, and of similar grades as formerly reported. The ore is taken out by contract. The mine was in a safe condition.

In November I again examined this mine. Captain Richards had a special outside appointment, and foreman George H. Behenna accompanied me through the mine. The latter gentleman has had extensive experience in mining,—first in the Cornwall tin mines, and since in Alabama, Montana and Michigan mines. The mine was in a safe condition, and conveniently arranged for work in addition to its neatness. A short space of the ladder-way required walling off, which Mr. Behenna informed me would be immediately done. The work done since my previous inspection was in drifting and stoping, and large bodies of ore were exposed. It is intended to sink the shaft an additional fifty feet during the winter, and explore the mineral at greater depths. The deepest working at present is 100 feet from the surface. At this date fifty men were employed on the day and night shifts in the mine, and seventy-five tons of ore lifted daily. Four air compressor drills were being used.

Extent of the underground works.

At my request, Captain S. Richards has kindly furnished the particulars of the nature of occurrences, method of operating the mine and the extension of work, bringing it up to the end of the year, together with the appliances used, the interesting descriptions of which are herewith inserted.

Respecting the nature of occurrences he says: "The ore body, which possesses an average thickness of seventy feet, strikes in the direction N. E. and S. W., and dips north-westerly forty-five degrees from the horizontal. This agglomerated mass of nickeliferous pyrrhotite and diorite is contained by diorite walls. The foot wall at certain points, as proved by mining operations, presents the appearance of a true fissured plane upon which, at some time or other, the ore body has moved, as evinced by the coarse flucan or attrited matter which separates the ore from the wall. In some places through the occurrence there exist large inclusions, horses or intrusions of diorite containing fragments of granite. These from their size and extent often render mining operations in their vicinity unsatisfactory when considered from a commercial standpoint."

Occurrence of the ore.

On the method of operating he says: "Our system of mining has hitherto been a modification of the cross-cut method with solid pillars. A shaft is sunk vertically on the occurrence, and drifts at the different levels are extended along the foot wall, the drifts at one level being connected by winzes and rises with the level above. Cross-cut stopes are then advanced from the foot wall to the hanging, leaving solid blocks or pillars between levels, and from wall to wall. These are cut through at intervals, forming arched excavations and sufficient material remains in situ to support the roof and overhanging wall. When convenient the larger intrusions are allowed to stand as pillars, but as nature bestows some of her gifts at too frequent intervals some of these barren rock masses are found when and where they are not wanted."

Method of working the mine.

Extent of
recent work-
ing.

On recent work he says: "The company has at great expense installed a water supply from a lake one and a half miles distant, and contrary to former winters work has been carried on almost uninterruptedly during the present season. Since last report (printed) at the second 100-foot level we have further extended our N.E. drift ninety feet, thus making on this side of No. 6 shaft a drift 125 feet in length. The drift is being continued. About thirty feet from the mouth of the drift a rise has been put up to the first level, and stoping from its sides is being done. At thirty feet from the breast of the drift another rise has been started, which is at the time of writing half way or twenty feet through. Shortly this rise will be holed to the first level, and more stoping ground will then be available. On the other side of shaft No. 6, at the 100-foot level, the S. W. drift has advanced sixty feet, making on this side eighty-eight feet of drifting. At a suitable distance from the mouth of the drift a winze connects the workings of the first and second levels, and stoping is progressing. The S. W. drift is still going ahead. The small drift mentioned in former reports is in reality a cross-cut, and this has been driven thirty-five feet further ahead, making in all seventy feet cross-cut in ore. We have commenced to sink below the second level, and are now eight feet down. We purposed to sink down to another level and prove by cross cuts and drifts the nature and extent of the ore body at a lower depth. Stoping is being done at the first level as formerly."

Appliances.

On appliances he says: "We have in use five compressed air drills. Drifting is done by hand labor. The mine is worked both by day and night, whilst crushing and sorting at the surface is done in the day time. About seventy men comprise the force at the mine, and thirty-seven of these are employed underground."

Miscellan-
eous notes.

The smelter had been closed from the end of January to the beginning of May. At the date of my visit they were running at the rate of 1,600 tons monthly. The bessemerized matte was shipped weekly. Ten or twelve thousand cords of wood were on hand. A total force of from 120 to 150 men were employed at both mine and smelter. Nothing had been added other than repairs and what was necessary for efficiently carrying on the work. The sanitary condition of the place was good. In the day school seventy scholars were enrolled. A neat church edifice had been built recently, and religious services and a Sabbath school were conducted every Lord's day.

In November I again went through the whole of the works, when the smelters were in full operation and all apparently was in excellent shape.

Mr. Henry W. Edwards, metallurgist, who has charge of this department of the company's work, has supplied an interesting description of the management of the ore—the process and requisites for smelting, with improvements, and labor employed, which I am permitted to subjoin.

Further de-
tails of pro-
cesses at the
Murray mine.

"The ore is received from the mine in small cars each carrying about one ton, running upon an elevated track raised by means of trestles some twelve feet above the level of the bottoms of the roast heaps. The floor of the roast heap is prepared by laying first a layer of six inches of small ore and upon this a layer of cordwood about eighteen inches thick. Upon this layer of wood the ore is dumped from the elevated track. About 1,000 tons of ore

form a roast heap. The heap being completed, the wood is ignited and fire is soon communicated to the ore, which will burn on an average for ten weeks. There is always a stock of some 6,000 tons of ore in heaps being built, burning and cooling, and being broken up for delivery to the smelting shed. The cost of mining and burning this large quantity of ore and carrying it in stock for so many months is in itself a heavy charge upon operations here.

The roast
heaps.

"As soon as a roast heap has finished burning and has cooled off it is torn to pieces and is transported in convenient quantities to the smelting shed, where there are two furnaces having a collective capacity of 160 tons of burnt ore daily. The fuel used in these furnaces is coke from Pennsylvania, which is much cheaper than Nova Scotia coke on account of the heavy freight upon the latter. In order to put the Nova Scotia coke on a footing to compete with that of Pennsylvania, a protective duty of at least twice the value of the coke at the ovens would have to be imposed, the present duty of fifty cents per ton being only an annoying burden of no benefit whatever to the Canadian producers.¹ In its transit here the coke has to pass over several railroads, and is subject to so many delays that we have to carry a heavy stock of it to insure that there shall be no interruptions of the smelting for want of fuel.

Fuel for the
furnaces.

"The burnt ore is smelted in the usual manner in small blast furnaces, the fused products being two in number, viz., slag, which is thrown away, and matte, which is passed on to the Bessemer process. The Bessemer plant at the Murray mine is the first of its kind applied to the treatment of nickel matte, and great efforts have been put forth to bring it to a successful issue. One of the materials required in this department is a good quality fire clay, which we have not been able to find as yet within our reach in the Dominion; we therefore import it from Ohio by the schooner load during the navigation season. The bessemerized matte is shipped to H. H. Vivian & Co's. smelting and refining works in Swansea, Wales, where the concluding operations are carried out.

Application
of the
Bessemer
process.

"During the present year the following alterations and additions to the plant have been made: (1) A steam pump and boiler at a small lake a mile and a half to the south, and a pipe conveying the water thence to the smelting works. This has been forced upon the company by the very bad quality of the water near at hand. (2) An extension of the roasting floors to accommodate a further quantity of three thousand tons of ore. (3) A new multi-tubular boiler of 100 horse power.

Alterations
and additions
to the plant.

"The engines employed in the smelting department aggregate ninety horse power. There are sixty men employed, about two-thirds of whom are unskilled laborers; the remainder are skilled workmen.

"During the year 1893 there have been three casualties, two men slightly burnt and one man severely."

Accidents.

Recently operations have been resumed on the property of the Drury Nickel Company, after it had been lying idle for nearly a year, with a force

Drury Nickel
Company.

¹ Under the amended Tariff Act of 1894, coke is put on the free list. This was done in response to petitions from mining companies and miners in the Sudbury District, and a memorial from the Toronto Board of Trade.

of about twenty-five hands under the direction of Mr. R. P. Travers. With the present output of ore and the quantity on hand when the mine was closed down the smelter will be kept constantly running. It is stated that the company's prospects are now encouraging, and that orders have been received for the entire quantity of matte to be produced for some time to come. For description of mine and plant see former reports.

Sheppard or
Beatrice mine.

The Sheppard mine is now called the Beatrice. This property comprises 320 acres, being lot 1 in third concession of Blezard, and is held in fee simple. A limited amount of prospecting on it had been done previous to the purchase by Messrs. Thomas Sheppard and E. H. Davis of Montreal, of the property from Mr. Babcock, who made the discovery of the nickel deposit in 1890 and immediately located it. The present owners have opened up the property by sinking a shaft 10 by 12 feet to the depth of 100 feet. At 40 feet from the surface two drifts have been run in east and west from the shaft, each about 10 feet. Below these drifts another has been run in 14 feet north. Mineral was followed in the shaft to the depth of the lowest drift. Each of the drifts has been in mineral, showing the existence of a large body of ore. Eight hundred tons of high grade nickel ore have been taken out and marketed in the United States, and there remains a quantity of lower grade on the dump at the mine.

Work was commenced by the present owners in 1891, and vigorously prosecuted in 1892 under the management of Mr. E. S. Townsend, who assumed control in February of that year. Work was continued with a force of about 30 men until April last, since which time the mine has been lying idle. In November, at the time of my second visit to that locality, it was expected that work would recommence at an early date.

The shaft is well timbered to the depth of 30 feet, at which point solid formation is reached. Work when resumed will be carried on in the drifts, as the lower part of the shaft was in barren rock.

A good road has been constructed to the Blezard mine, a distance of two miles in a southerly direction, over which the ore was hauled by sleighs in the winter to the point of shipment on the cars. For description of plant see former report.

Tam O'Shanter
mine.

In a recent issue of the Sudbury Journal it is stated that some English capitalists are negotiating for the purchase of the Tam O'Shanter property, which is in the township of Snider, three miles from the Copper Cliff and six from Sudbury. The discovery was made last season, and from present appearances there is a large body of mineral, the surface ore running as high as $3\frac{1}{2}$ to 4 per cent of nickel.

The October number of the Canadian Mining Review contains a description of "Our Mineral Exhibits at the World's Fair" from which the following interesting extract is taken:

"The whole of this section was well worth seeing. Ontario had a strikingly good exhibit. This go-ahead Province certainly did credit to herself. Mr. A. Blue, Director of Mines, Commissioner Awrey, and the able staff of

The mineral
exhibit of
Ontario at
Chicago.

which Mr. Boyle was a conspicuous figure, have reason to be proud of the result of their months of arduous labor. The Ontario court presented an attractive front, and the nickel trophy in the centre formed a unique and massive pyramid, impressive to the sight, and never to be forgotten by the passer-by. Iron ores, copper, mica, graphite, zinc, galena, asbestos, building stone, petroleum and its products, fire and brick clays, soapstone and apatite, or phosphate of lime, with its products, were shown in abundance and tastefully and artistically displayed. Due regard to the economic aspect of the exhibits was to be seen on all sides. The gold and silver ores also formed salient features in this court, whilst salt, marbles, sandstones, granites, clays and cement stones served to complete the exhibits of the Province whose mineral wealth is only now just being appreciated. Ontario's display of its mineral wealth was indeed an instructive one. To the economic collection was added a mineralogical one of considerable extent, furnished by a private collector in the person of Mr. W. G. Kidd of Kingston.

"The nickel trophy deserves more than a passing mention. It was undoubtedly the most complete and extensive display of the kind ever made in the world. The exhibit of the only country which could compete with Canada was New Caledonia, a colony of France, and whilst its exhibit was certainly instructive and interesting, yet it was small and inconspicuous. Some of Ontario's specimens of nickel ore weighed 6,000, 8,000 and 12,000 lb. respectively, and gave a capital idea of the extent and richness of our far famed nickel deposits. Nickel anodes, nickel shot plates and ingots of nickel were also exhibited."

The nickel trophy.

IRON ORES.

The following, taken from the Kingston Whig, is of interest, in view of the probable early access to the markets of the United States for our iron ores :

"To-day G. A. Longnecker and John Morris of Pennsylvania were in the city. They purchased a car-load of magnetic ore, which will be got at the Wilson mine near Calabogie. The ore will be taken to Pennsylvania, tried in the furnace, and if the test is satisfactory they will buy an iron ore property in the vicinity of the K. & P. R. It is thought a boom in the iron ore business is close at hand. It will begin when the duty is taken off iron ore going from Canada to the United States. This change may be made by the Cleveland Administration, and some iron men are confident the duty will be removed."

Wilson mine.

The iron ores on the Kingston and Pennsylvania broke railway.

"On valuable outcroppings of the Atik-ogan iron range, lying along the Atik-ogan river in Ontario, nearly a hundred miles north of the Minnesota boundary and fifty miles from the Canadian Pacific line, options were given three years ago to a Belgian syndicate, reported at that time to be of great strength. These options expire with October 31st, but arrangements are being made looking to a continuance. The Belgians are waiting for a decision in tariff changes, particularly on the import of iron ores, before closing their purchase." For the above I am indebted to the N. Y. Engineering and Mining Journal.

Atik-ogan iron range.

The following excerpt is from an excellent article on iron mining in Ontario, which appears in the April number of the Canadian Mining Review :

"No one who considers the situation with an unbiased mind can do otherwise

Freer trade
relations a
necessity.

than come to the conclusion that in whatever way freer trade relations with the remainder of this continent would affect other industries and interests in Ontario, they could have none but beneficial results upon iron mining. The close competition which the opening up of the new sources of supply within the past few years has given rise to in the United States markets has made it impossible to raise iron ore and ship it across the lines in face of a duty of 75 cents per ton, and the result is that the iron mines of central and eastern Ontario within easy distance of the great smelting centres in Ohio and Pennsylvania have been forced not only to cease raising ore to the surface, but have even in some cases been obliged to keep on hand considerable quantities which had accumulated at the mouth of the mines when last in operation. Were commerce as free between Ontario and the United States as it is between Michigan and the rest of the Union, it is surely reasonable to suppose that results would ensue in Ontario similar to those which have followed in Michigan. Not only could iron ore be exported, which in itself would be a very great boon, but with a large outlet for charcoal iron, for the production of which the facilities possessed by Ontario are unequalled, the business of smelting would receive an impetus which could not be imparted to it in any other way. The report of the Commission on the Mineral Resources of Ontario (1890) sums up this aspect of the situation very concisely in the following words: 'The beneficial influence to be exerted upon the interests of the Province by the stimulating effect certain to be the result of the breaking down of the hostile tariffs between Canada and the United States would, in the case of the export of iron ore, and probably of pig iron also, be certain to promote the prosperity of Ontario to an extent greater than any but the most sanguine would venture to predict.' "

MICA.

Sydenham
mine.

The Sydenham mine is situated four miles by water and eight by road from the village of Sydenham. It was formerly owned and worked by Lacy & Smith, but has been lying idle for a couple of years past. The property embraces one hundred acres, and a part of it is worked for agricultural purposes by the present owners, Messrs. Webster & Co., who purchased it in December last.

The head office of the present company is in Kingston. Work was begun by Messrs. Webster & Co. on the 1st of January last, under the management of Mr. J. E. Chown of Sydenham, with Captain John Harris as foreman, who had the former charge for eight years when worked by Lacy & Smith. It was in fairly good condition, but required the refitting of some ladders, walling off the ladder-way from the shaft, and putting in a few additional timbers in insecure places, all of which the foreman assured me should have early attention. The recent heavy rains had caused a good deal of dripping, and the accumulation of a large quantity of water, but the Cameron pump in use discharged it with ease.

Extent of the
workings.

The main shaft had been sunk an additional 20 feet, making a total depth of 180 feet. In the 100-foot level the drift had been extended eight feet, making its total length in an easterly direction from the shaft 200 feet. A few tons of mica had been obtained from this cutting. Stopping had also been

done in this level, with a good yield of mica. At the distance of 95 feet from the main shaft an open cut had been made 8 by 24 feet and 30 feet deep, and the foreman stated that an excellent deposit of mica had been exposed, but the work at this point was abandoned on account of the inflow of water. Another opening south about 200 feet from the first, 10 by 25 feet and 18 or 20 feet deep, was being worked, from which about three tons of amber mica had been taken out. The mineral showing at this stage of the work was good. A horse derrick was used. Considerable prospecting on the lot had been done by stripping and cross-cutting, with excellent showings of mica. All surface drilling was done by hand. The old buildings and machinery are being utilized for present operations, and the boarding house and office have been nicely refitted. There is also a store, a shaft house with annex for boiler and engine, a cobbing house with bedrooms attached, a house for changing clothes, and a blacksmith shop, etc. The magazine is about 300 feet from the other buildings.

The hoist is by bucket with guides, and holds about 1,000 pounds at a lift. By an excellent automatic arrangement the mineral is dumped into a hopper, from which it runs into a car and is conveyed over a tramway to the cobbing house or to the dump. After being roughly sorted it is taken either by scow across the lake, or carted by road to the mica house in Sydenham, where it is carefully sorted and boxed or put up in barrels for shipment.

A 35 h. p. boiler with engine is used for pumping and hoisting. Two Ingersoll air compressor drills were in use. Twenty men were employed in May at the date of my visit, fifteen at mining and the others at outside work; the former receiving \$26 and the latter \$20 per month with board.

About 300 cords of wood were on hand, two cords being used per diem on the day and night shifts.

On May 22nd I visited the Levett & Davis mine on lot 3 in the fifth concession of Burgess, on the shore of Rideau lake, 7 miles south of Perth. Recently the mine has been purchased by Messrs. Levett & Davis, and they had been working it with a force of seven men for six weeks, during which time about twenty tons of amber mica had been mined and taken via the lake to the mica house at Perth. It is there dressed and boxed. About eight tons were on hand at the date of my visit, the rest having been sold. Excellent facilities are had for loading the ore, as the shore is so bold that the small steamer John Haggart which plies on the lake can moor at its edge.

Levett &
Davis mine.

In former years the property had been worked for both mica and phosphates, and considerable quantities had been taken out. The surface workings have been extended over 20 or 25 acres. The principal place of working is about twenty rods from the landing, where an open pit has been sunk about 25 feet, with surface opening 20 by 30 feet, and narrowed to 10 by 20 feet at the bottom. I examined several other openings on the property from which fine crystals had been taken, three of which were some thirty rods from the main workings. The vein of mica is from 8 to 10 feet in thickness, and some very large crystals have been removed, one lump being two by three feet and weighing 450 lb. The present developments indicate a large output as the work proceeds.

Working on
the property.

A good boarding house was in process of construction at the shipping point on the lake, to which would be annexed an office; also a building for storage with good stabling attached, a blacksmith shop, etc.

Mr. Levett has the general management, and Mr. A. Gibson charge of the ground work.

Martha mine. On May 22nd I visited the Martha mine, which is situated on the north-east half of lot 13 in the sixth range of North Burgess, a distance of ten miles south of Perth. Surface prospecting work had been done at intervals since 1871, extending over about 40 acres for phosphate, and a very considerable quantity had been taken out by the several operators. In December, 1892, the property was purchased from Mr. D. George MacMartin by the Lake Girard System, a company having its principal office in Ottawa. The present owners have worked the property since early in January last with encouraging results for both amber mica and phosphate under the management of Mr. MacMartin, with Peter Powers as captain of the mine. The mica is carefully culled, hauled to the town of Perth and shipped via the Canadian Pacific Railway to Ottawa. The phosphate obtained is of excellent quality.

Works and
machinery.

The place of working at the time of my visit was on the rear of the lot, which contains 100 acres, the mineral right only having been purchased by the present owners. In an open pit, 33 by 40 feet and 32 feet in depth, sixteen miners were engaged at work, but the total force employed was twenty men. The rock was lifted by two whims worked by horse power. No brakes were used, but two suitable ratchets had been provided, which I was informed would be immediately attached to them. From 40 to 50 tons of mineral and rock were being taken out daily. This mine gives promise of an excellent yield. Six or seven hundred cords of wood had been provided, and suitable machinery with which the work could be conducted on a much larger scale would be brought on at an early date.

The old boarding house would soon be displaced by a large new one, then in process of construction, at the distance of a quarter of a mile from the other. A good magazine had been put up 200 yards from the workings. Good stables, a blacksmith shop, etc., had been built. Stanleyville P. O., Lanark County.

O'Connor
mine.

Mr. Anthony O'Connor owns in fee 100 acres of lot 1 in the third concession of South Burgess, on which he was mining for mica with a force of five men when I visited the place in May. A little prospecting had been done the previous year. For about six weeks work had been carried on and an opening had been made 25 by 36 feet and worked to the depth of 22 feet. The mica vein at the place of working is about ten feet wide, and by about one hundred in length, and five or six tons had been taken out and sold. A derrick is used for lifting the rock and ore. Several other surface openings show mica, and in one a body of graphite has been exposed. This property is 2½ miles south from Hagarty's Wharf, and 4½ miles from Oliver's Ferry.

O'Mara mine.

The O'Mara property comprises 100 acres, being part of lot 5 in the first concession of South Burgess, and is owned by Mr. James Jones in fee simple.

The mineral right has been leased by Mr. Patrick O'Mara, and the mine has been worked by him with a force of four or five men since December last. Up to the date of my inspection in May, 25 tons of mica had been mined. The ore is culled at the mine, a part hauled to Perth, a distance of fifteen miles, and the remainder to Oliver's Ferry, six miles away. A portion of it has been marketed in Boston, Mass., and the rest in Kingston. The ore when culled is separated into three qualities, the value of which per ton is stated to be as follows: No. 1, \$250; No. 2, \$110; No. 3, \$25. About equal parts of No. 2 and No. 3 were obtained, and a lesser proportion of No. 1.

Work was being done on the northerly part of the lot, and an open cut had reached the depth of 35 feet, with some additional surface stripping, exposing a fair showing of colored mica. The lifting is done by derrick. Very little water interferes with the workings. Mr. Peter Adams supervises the work at the mine.

A mica house, blacksmith shop and stables have been built. Cranworth P. O. is within half a mile of the mine.

On May 23rd I visited the Canton mine, situated on lot 1 in the fourth concession of South Burgess. Mr. J. E. Chown of Sydenham has the general management for the owners, Messrs. Webster & Co., who have purchased the mineral right of 100 acres. Five men and the foreman, Mr. Samuel Cordick, were clearing out some old pits, preparatory for more extended work on the mine, which is now being worked chiefly for mica. Formerly a considerable quantity of phosphate had been mined. A portable boiler and engine had been brought on, to be used for pumping water, drilling and hoisting at the workings.

One opening of 22 by 37 feet at the surface and narrowing towards the bottom had reached the depth of 40 feet, but was now nearly filled with water. Last fall 40 tons of phosphate, with some mica, were taken from this cutting, which was then worked for two and a half months with a force of fifteen men. Several other openings for over 100 feet on the surface had been made, on which work will be continued for mica, as the showing is good.

This property is about 100 feet above the surface of the lake, and yet the inflow of water in the cuttings is a serious impediment to the work.

I had the pleasure of meeting Mr. Watson of Boston, one of the principal members of the company, who was carefully examining the property, as well as the old Smith & Lacy mine, which the company had recently purchased.

The description of the two following properties is given in the Ottawa Mining Review for December:

"Mr. John McKay of Eau Claire is working his lot, No. 9 in the first concession, township of Calvin, for white mica. The crystals are irregularly distributed in veins of a coarse granite, which have a general northeast-southwest direction, and vary in width from four feet up to 25 feet. One vein, with elliptical section shows a length of 110 feet, and an average width of 15 feet. The crystals taken out of this vein have a light green color, and the single laminae contain frequently green spots; they are not very large in

Canton mine.

Workings on the location.

White mica in Calvin.

size but yield a good average of clear sheets. The vein has been tested by a shaft of 25 feet depth, and it seems to continue regularly. Another vein in the north part of the property has a width of 25 feet, and has been traced for about 450 feet. The output for three months, with an average labor of five men, amounted to 3,500 lb, which have yielded 25 per cent. of trimmed mica.

"Mr. F. B. Hayes of Ottawa has been working for about two months on lots No. 16 in the first and second concessions of the township of Calvin. Six parallel veins containing white mica crystals distributed have been uncovered. The principal opening consists of an open cut of 30 feet by 10 feet wide on a mountain slope. Work has been suspended for the winter on account of the heavy snow fall. The quantity and quality of the mica taken out give reason to believe that the property, if developed, can be worked with success. Operations will be resumed next spring."

GRAPHITE.

Graphite in
North Elms-
ley.

At the time of my visit to a graphite property in the township of North Elmsley in May work was being conducted under the management of Mr. John F. Torrance, of Montreal, a graduate of the Arts and Science department of McGill College, as well as of the School of Mines at Freiburg, Saxony. He has visited the mining districts of East India and British Columbia, and has also acted on the Geological Survey of the Dominion.

Mr. Torrance informed me that application had been made by Montreal and Boston capitalists for a charter for a company to be known as the Northern Graphite Company, with a capital stock of \$95,000.

Six or eight men were actively engaged in sinking bores on lot 22 in the sixth concession of North Elmsley, which is out from Perth about six miles, and one mile from Oliver's Ferry. Bores have also been made on lot 21, and one bore on lot 23 in the seventh concession. The Company has leased 1,200 acres with the option of purchase, some of the lands lying on both sides of the Rideau. The formation is chiefly limestone. In all eight bores had been put down, averaging from 50 to 100 feet in depth. The surface showings were excellent, and the borings confirmed the existence of graphite to the full depth to which they had been sunk. Some of the cores also gave showings of considerable deposits of phosphate.

The rock is ordinary gneiss, associated with limestone. The bands of gneiss contain the graphite. On lot 22 the formation is anticlinal. There were good surface showings of graphite on lot 1 in the sixth concession of Burgess, which were going to be fully tested.

GYP SUM.

Paris mine
and mills.

Early in December I visited the Paris plaster mine and mills. At the latter about a dozen men were employed. No change has been made in the process of manufacturing alabastine. The demand for it has increased fully 50 per cent. during the year. It is prepared in the form of a fine powder, then put up in 5-lb. packages and is ready for use with the addition of cold water only. It is largely taking the place of kalsomining, papering and other

finish upon house ceilings, walls and other surfaces, making a permanent and neat coating. It is as hard as the wall itself, and when necessary can be replenished by another coating of the same material without the old being removed. Before being put into packages it is prepared in different colors to suit the taste of those using it. Directions accompany each package, and it may be applied by any party needing it. Another article, used for the extermination of potato bugs, is prepared at the mill. It consists of plaster, Paris green, and other material ground together, a product new in Canada but widely used in the United States and extensively prepared at Grand Rapids, Mich. It is put up in barrels containing 300 lb. each and labelled "Church's Potato Bug Finish."

A new plant for calcining the plaster, of about one ton capacity per hour, has been put in the mill during the year by Mr. Hare, who has charge of the milling department. After the plaster is ground by the buhr stones it is elevated into a hopper, from which it is introduced by a feeder into the long fire box, and by a lateral worm conveyor it is slowly carried along about 40 feet and returned by a similar process through the fire box, making its transit of 80 feet subject to an intense heat. The plaster is thus evenly and thoroughly calcined by a continual flow. The fire box is heated by gas oil, of which a barrel containing 40 gallons is used in ten hours. The demand for this article has largely increased during the year. It is now being shipped in car lots to Toronto and other places for sale. The white gypsum from which this is manufactured is brought from the beds on the Grand river in the vicinity of Cayuga. This is the only plaster calcining establishment in Ontario.

I directed that an open cage entrance on one of the flats with a stairway and one belt should be fenced off with proper railings.

Three men were working in the mine by contract at 90 cents per ton, taking out about five tons daily. The new drift referred to in the former report had been abandoned on account of the inflow of water. An important change has been made in the old drift by which the present approach to the face of the deposit was shortened to half the distance of the old one, and much better ventilation in the mine secured. At the place of working the layer of plaster was about four feet in thickness and opened to the distance of 200 feet. I advised that a cross-cut be made to ascertain the extent of the deposit, and if the field of mineral was found to be extensive then to reconstruct the drift at once. It is low and inconvenient, and requires additional supports. The roof at the place of working was fairly well supported. Some parts of the old workings had broken down. About 1,000 tons of gray plaster had been taken out and ground during the year for fertilizing purposes. Some 300 tons ready for sale were still on hand. It was expected that double the quantity would be mined in the coming year.

Mr. T. W. Wheeler continues in the management of the company's operations in Canada.

Excelsior mine is on lot 2, Grand River road, $2\frac{1}{2}$ miles east of Cayuga. It is owned by the Adamant Manufacturing Company of Syracuse, N.Y., and is now leased by the Alabastine Company of Paris. This lease expires

Alabastine.

A new process of calcining plaster.

Mining the gypsum.

Excelsior mine.

on August 1st, with option of renewing. Mr. John A. Nelles has the management of the mine, and had been working it on contract with a force of four men since September 1st. At the date of my visit, December 12th, 200 tons of white plaster had been mined, and was being delivered at the Cayuga station on a contract of 1,000 tons to be used at Paris for adamant purposes. Mr. Nelles provides all the material for operating and keeping the mine in a safe condition. Some parts of the mine required repairs, as the property had been lying idle for three years until the recent working. The small quantity of water that runs into the mine is drained into two sumps, over which pumps driven by windmill power at the surface are used. These when in good condition for work have proved sufficient. At each pump shafts have been sunk from the surface, and are well timbered up, affording a safeguard against accident as well as excellent ventilation to the mine. The tunnel is run in from the level surface in a northerly direction at a dip of one foot in ten for the distance of 175 yards, where it intersects the bed and continues an additional 200 yards, following the layer of plaster. At the foot of the incline 175 yards from the entrance another drift has been extended on an easterly course for 200 yards to the place of the present workings, which is at a depth of 60 feet from the surface. The gypsum is hauled out by horse car over the tramway.

Teasdale
mine.

Teasdale mine is situated four miles east of Cayuga, on the Grand river. Three men were engaged at the mine and were taking out about six tons per day of white gypsum at the date of my visit in December. Only one ton of waste rock was broken out to ten tons of plaster. The drift is started in a ravine three or four feet above high water in Nolan's creek, and is driven in at an incline of one foot to the 100 feet. At the distance of 100 yards from the entrance a pump is placed, driven by a windmill on the surface, which is 35 feet above the workings at this point. The drift is continued in the same south-westerly direction another 20 yards to the present place of working, at a slight incline upward, giving drainage in both directions to the pump, which is of sufficient capacity to keep the mine free from water when running. The uncertainty of the power prevents working the mine continuously. Great care has to be exercised in not breaking up the floor of the drift, which is of solid rock, as there appears to be a fountain of water some two feet below, which upon being opened quickly floods the mine.

The continuance of the drift with its present upward incline may overcome the water inflow which has hitherto seriously impeded the work. The layer of gypsum, which is from three to four feet in thickness, follows to some extent the surface incline upward. It is supposed that the large quantity of water underneath the plaster is retained by the dam placed across the river at Dunnville, ten miles below the mine.

Two test shafts on the top of the hill have been sunk to the bed, some distance apart, which would indicate that the plaster extends over a wide area. About 400 tons have been taken out of the workings, of which nearly 100 tons remain at the pit's mouth ready for shipment. A horse tramway is used in taking out the mineral, a car load being 1,500 lb.

The property is under lease by the Alabastine Company of Paris and the mining is done under contract by Mr. John Walton, who furnishes all requisites to keep the mine in order. The drift is well timbered and the work carefully conducted.

I inspected the Martindale mine on the 13th of December, when but two men were employed in mining. About 250 tons had been taken out during the year, and about five tons daily were being removed at this date. Some parts of the old workings had settled down, and others had been abandoned on account of their unsafe condition. A few places in the long drift leading to the present working ground required refitting, the timbers having become weakened by decay. This mine requires a thorough overhauling, the expense of which the workmen, though mining by contract, claim should be borne by the owner, who apparently is indifferent about it. I requested that some of the more dangerous places in the drift should be secured at once, which the men consented to do. The immediate place of working was well supported.

At the date of my visit to the Garland mine in December, two men were employed by contract at the works. The place of working was 150 yards from the entrance, and the mineral was taken out by horse tramway at the rate of six or seven tons daily. It is ground in the mill at Caledonia, and is used largely as a fertilizer. The layer of gypsum of about four feet in thickness is overlaid with a bed of firm clay or hard pan, which in places as the gypsum is removed softens on coming in contact with the air and settles down into the space below. Much care has to be taken to secure the roof at the places of working, which is done by building up walls of the waste rock and timber supports.

Upon close examination I found many of the small timbers in the entrance drift in a very decayed state. I gave instructions to the contractor to have them replaced with firm supports, and also wrote to the owner of the property, Mr. Nicholas Garland of Toronto, stating the dangerous condition of this part of the mine. There is yet a large field of gypsum in this property. *

The Merritt, the Glenny and the Mount Healey mines are lying idle.

I have the honor to be, Sir,

Your obedient servant,

A. SLAGHT, Inspector.

Waterford, February 10, 1894.

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